COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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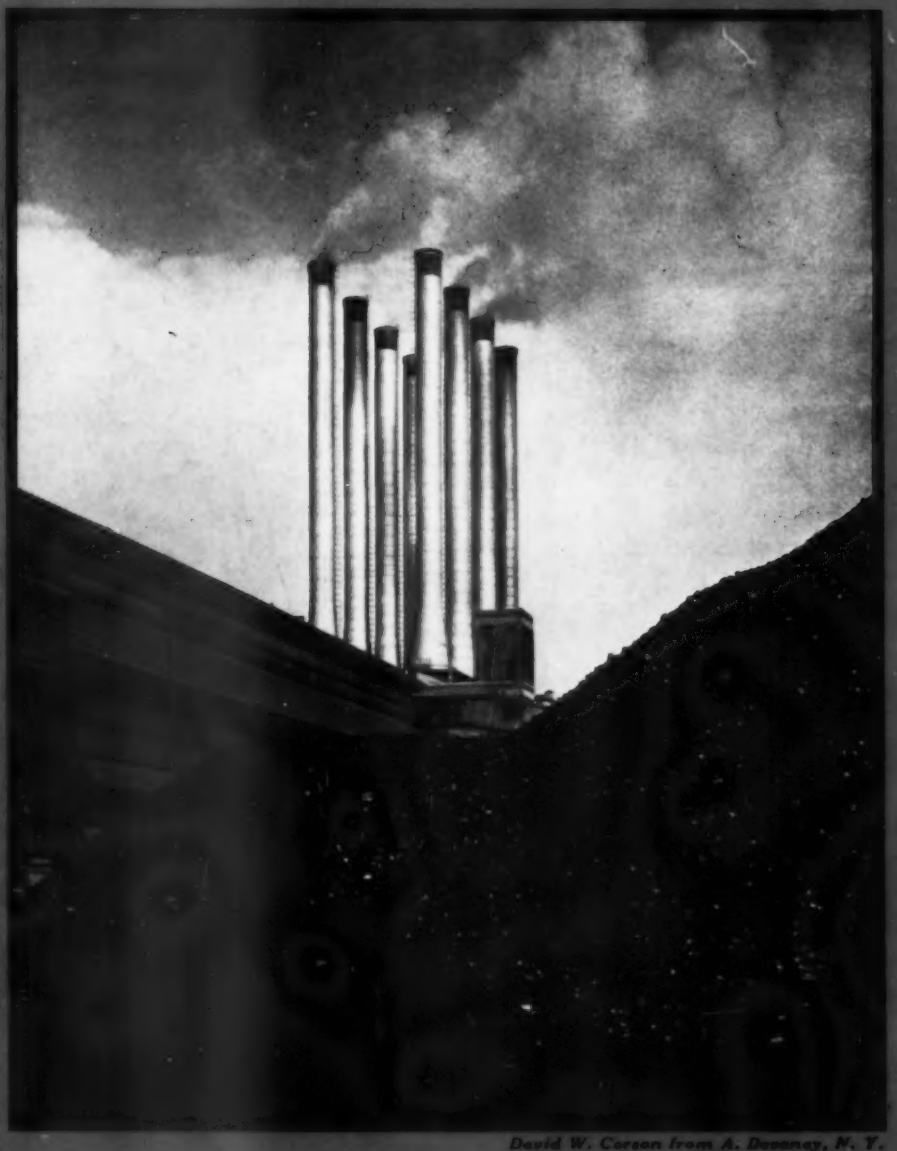


David W. Corson from A. Devaney, N. Y.

Experience with High Steam Pressures ▶

Pulverized Coal in Transportation ▶

Synthetic Fuels ▶

Recent C-E Steam Generating Units for Utilities

PORT WASHINGTON STATION

WISCONSIN ELECTRIC POWER COMPANY

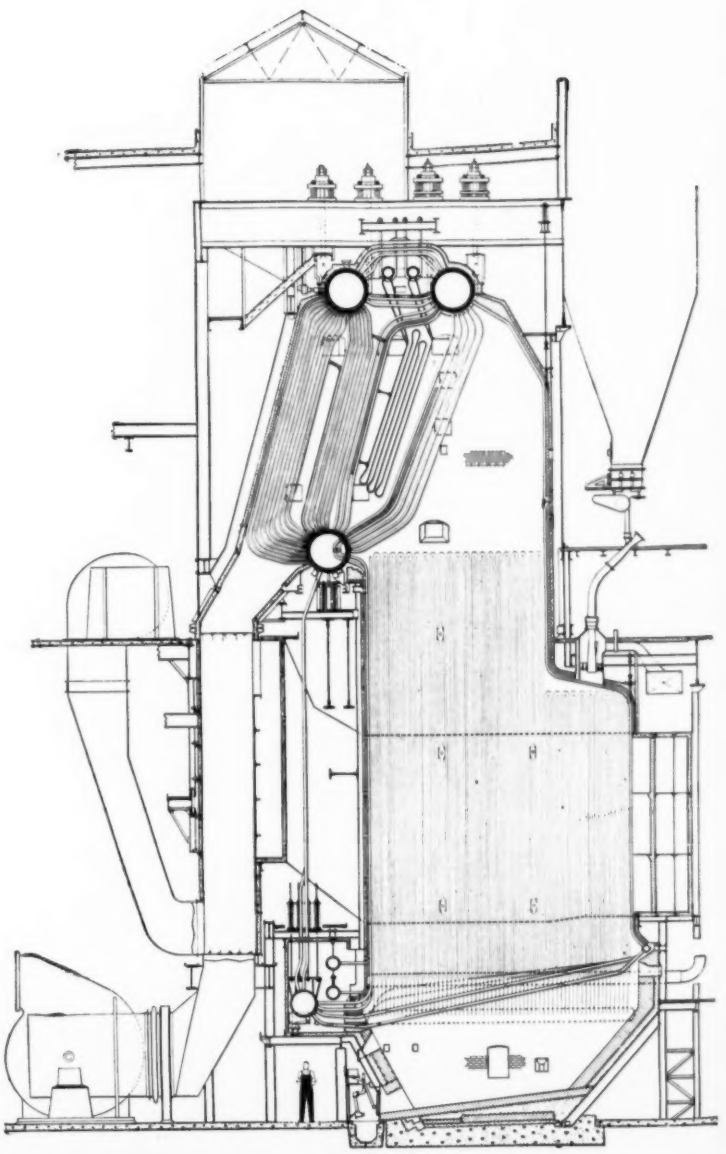
THE C-E Unit, illustrated at the right, is now in process of construction in the Port Washington Station of the Wisconsin Electric Power Company at East Port Washington, Wisconsin. It is the fourth C-E unit of similar design ordered for this plant since its opening in 1935.

This unit is designed to produce 600,000 lb of steam per hr at 1400 psi and 900 F. This is a higher pressure and temperature than the previous units, which operate at 1300 psi and 830 F.

The unit shown — as well as its predecessors — is of the 3-drum type with dry bottom furnace. Pulverized fuel firing of the storage system type is employed, using C-E Vertical Burners, C-E Raymond Roller Mills and Type R Feeders. C-E Plate Type Air Heaters supply heated secondary air, which is introduced through a zoned front wall.

The Port Washington Station has long been regarded as the world's most efficient steam-electric power station, maintaining its distinguished record year after year.

B-212



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C-E PRODUCTS INCLUDE ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; GAS SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME TWENTY NUMBER FIVE

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FOR NOVEMBER 1948

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WATER GAS PLANT INSTALLS

28th COPES FEED WATER REGULATOR

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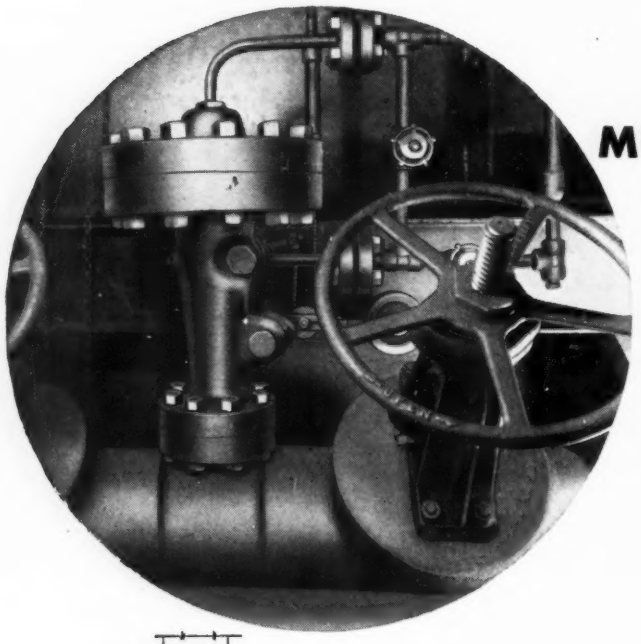

The twenty-eighth COPES Feed Water Regulator installed by a well-known gas company was for one of the first water-gas plant boilers ever to operate at 625-psi and 700-F. A two-element Flowmatic Type D-O, it gave excellent control of both feed flow and water level for the tar-fired Riley Type RP Steam Generator. Another Flowmatic has since been installed on a second 625-psi boiler.

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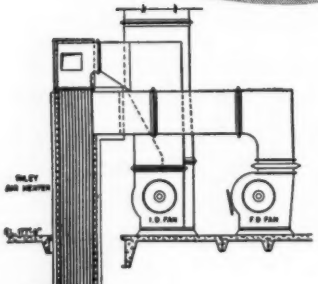
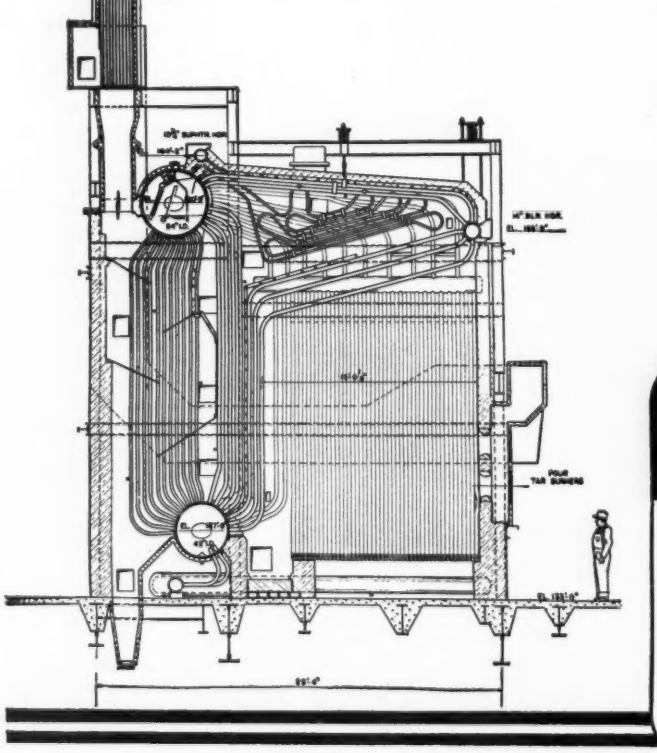


BULLETIN 483 tells the story of this Flowmatic on the Riley unit shown below, and gives the history of COPES in this important gas works. Write for it.



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EDITORIAL

Capacity vs. Demand

October figures showed the curve of total electric output still pointing upward approximately eleven per cent, on a nationwide basis, above that of a year ago. Meanwhile, despite completion of a number of new installations, capacity has increased only about five per cent. This will be further amplified by the time the winter peak arrives, but hardly enough to warrant a feeling of security in certain localities. In fact, some utility companies are already seeking voluntary agreements with customers to curtail demands during hours of anticipated peaks.

Now that election campaigning is past, let there be an end to recriminations that the utilities have fallen down on their job; and instead an admission that all concerned are doing their utmost to serve mounting electric demands in a period of unparalleled activity.

Pulverized Coal in Transportation

The third and concluding article of the series by Mr. Humphreys on early development of pulverized coal firing, which appears in this issue, indicates that considerable attention was given this method of firing in the marine and railway fields in the late '20's; even though no traces remain today.

What were the reasons for its disappearance from these fields, while it has become dominant in the stationary power plant field?

In so far as concerns marine applications the reasons were apparently both technical and economic. Among the technical obstacles were inadequate furnace volume, difficulty in pulverized coal distribution, and the problem of handling the raw coal to meet shipboard conditions. The economic drawback was that fuel oil costs during that period declined sufficiently to remove the incentive to pursue further development in this direction. Notwithstanding these factors, a number of the ships so equipped operated for varying periods with apparent satisfaction.

In the railway field pulverized coal got a somewhat earlier start, but development work appears to have been suspended in the period of Government operation, during and immediately following World War I; and when the railroads were subsequently returned to their private owners they were in such financial straits that funds for further development of this kind were not then available. Meantime, pulverized coal firing had taken hold of the stationary power plant field with such force as to command the undivided attention of the two or three pioneer firms that had previously given attention to its use in the railway field.

Had engineers then known what they do today about the art of firing pulverized coal, it is likely that it might have survived as a competitor of fuel oil in the marine field despite advantages in handling the latter.

In the railway field the spectacular growth of diesel engine applications during the last few years has been such that pulverized coal, applied to the conventional locomotive, might have found competition difficult. However, if the experimental work now being conducted by Bituminous Coal Research on a pulverized-coal-fired gas-turbine locomotive meets with ultimate success, this method of firing will have achieved a come-back after remaining dormant in this field for thirty years.

Central Station Operating Figures

A chart recently released by the Federal Power Commission analyzes graphically the source of revenue and the disposition of operating expenses of Classes A and B privately owned electric utilities during the last five years.

Although the total revenue during this period increased by approximately a third, there was practically no change in the net operating revenues after deducting such items as fuel, salaries and wages, depreciation, taxes, and miscellaneous operating expenses.

Increases in residential, commercial and industrial sales all seem to have contributed to the higher total revenue in about the same proportion during the last two years, although industrial power sales fell off to some extent during the conversion period following termination of the war.

The total fuel cost appears to have just about doubled during the last three years. This, obviously, is not all attributable to advancing fuel prices as the load has also increased; but not to that extent. Expenditures for salaries and wages are up nearly fifty per cent, whereas there is little change in total taxes.

The data upon which these curves were based deal with the industry as a whole and may be at considerable variance with individual cases. Furthermore, they are operating figures and do not take into account certain fixed charges that must come out of net operating revenues. With the large amount of new construction now in progress the fixed charges will increase, although the increased economy of the new stations and units should tend partly to offset the higher fuel costs.

Operating Experience with High Steam Pressure

In a paper presented October 29, 1948, at a joint meeting of the Institution of Mechanical Engineers and the Institution of Electrical Engineers (Great Britain), W. N. C. Clinch[1] related operating experiences and comparative performances of 50,000-kw and 60,000-kw units at Brimsdown "A" and "B" Stations, respectively, where steam is furnished at 1900 psi, 930 F by Loeffler reheat boilers, and at Willesden Station where two 32,000-kw turbine-generators are supplied with steam at 1300 psi, 950 F by two non-reheat natural-circulation boilers of the Cantieny design and three La Mont forced-circulation boilers. The overall efficiencies were comparable, but the Willesden units showed somewhat higher availability. Following is a digest of the salient points of the paper.

BETWEEN 1938 and 1944 the Northmet Power Company placed in service high-pressure installations comprising a 50,000-kw unit at Brimsdown "A" Station; a 60,000-kw unit at Brimsdown "B," both operating at 1900 psi, 930 F at the turbine with reheat at 160 psi; and two 32,000-kw, non-reheat units at Willesden Station operating at 1300 psi, 950 F. In each case the main considerations were economy in coal consumption and in circulating water requirements, since it was necessary to employ cooling towers.

Studies of various high-pressure plants on the Continent led to the decision to adopt the Loeffler design of boiler for Brimsdown "A," two such reheat units of 210,000 lb per hr maximum continuous rating at boiler stop valve pressure of 2000 psig, 940 F being purchased from the British licensee, the Mitchell Conveyor and Transporter Company. A simple diagram of the Loeffler boiler circuit is shown in Fig. 1.

[1] Divisional Controller, Eastern Division, British Electricity Authority.

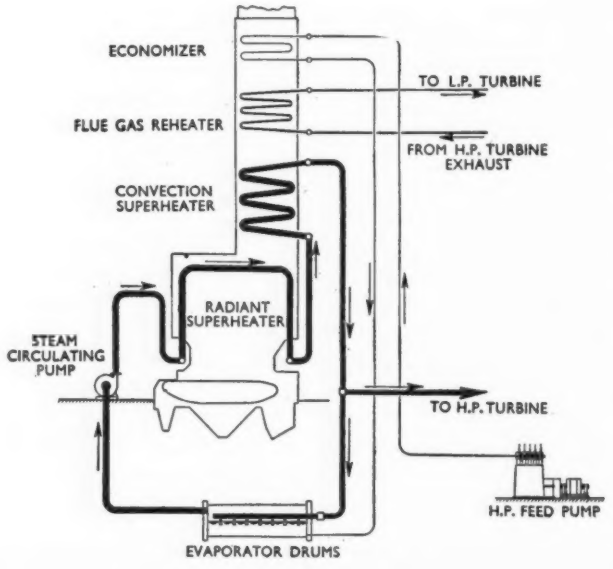


Fig. 1—The Loeffler boiler circuit

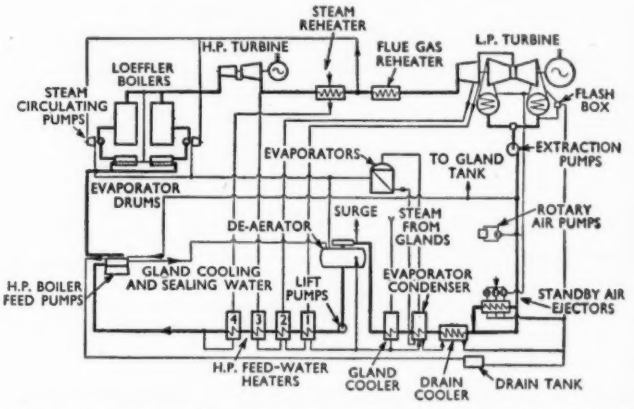


Fig. 2—Steam and condensate system of Brimsdown "A"

Although this design of unit was well adapted to pulverized coal firing, available space precluded the installation of adequate electrostatic precipitators or flue-gas washing equipment; hence it was decided to employ chain-grate stokers with standard cinder arrestors incorporated in the induced-draft fans.

The electric generating unit consisted of a 1900-kw, high-pressure turbine exhausting at 160 psi through a steam reheater in series with a flue-gas reheater to the 34,000-kw, low-pressure condensing turbine. While it was realized that the full efficiency available from the initial steam conditions was not attainable with an intermediate pressure of 160 psi, this was selected with the object not only of utilizing steam from the plant's low-pressure boilers for starting up, but it also provided operating flexibility should either the new high- or the low-pressure turbines be out of service. A diagram of the steam and condensate system is shown in Fig. 2.

Before this installation was in service authorization was received in 1938 for the installation of a 60,000-kw extension to the Brimsdown "B" Station. In essential features this somewhat larger extension was similar to that at Station "A" except that the steam reheater was omitted and a modified drive was adopted for the steam-

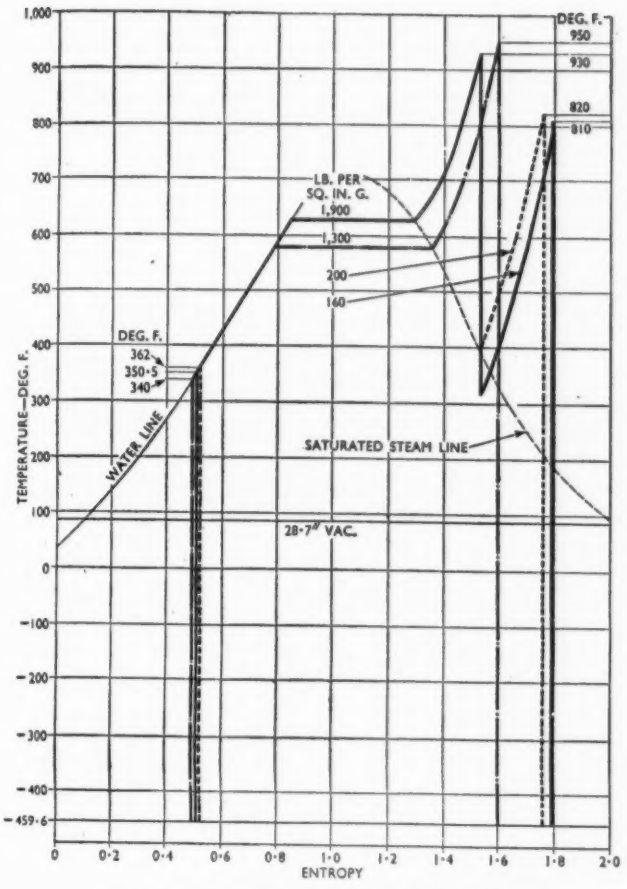


Fig. 3—Ideal steam cycles compared

Solid line, Brimsdown "A" with 48.62 per cent efficiency. Dotted line, Brimsdown "B" with 49.23 per cent efficiency. Dot-and-dash line, Willesden with 47.56 per cent efficiency.

circulating pumps of the two 250,000-lb-per-hr Loeffler boilers. Furthermore, the intermediate pressure between the 17,000-kw high-pressure and the 39,190-kw low-pressure turbines was 315 psi to correspond with the existing operating pressure of the older equipment at Station "B."

At about this time consideration was also given to extending the company's Willesden Station which then was rated at 38,500 kw. Here again it was necessary to select a cycle economical in circulating water requirements because cooling towers were to be employed. Steam conditions of 1300 psi, 950 F at the turbine, without reheat, were selected. Comparison with the Brimsdown "A" and "B" cycles is shown in the temperature-entropy diagram of Fig. 3.

At Willesden the higher steam inlet temperature, without reheat, results in a wetness fraction at the turbine exhaust approaching the maximum value permissible with regard to erosion of the leaving blades, but for which it was possible to make satisfactory provision in the design of the final stages. The circulating water requirements figured 11 per cent less than for Brimsdown "A" and nearly 5 per cent less than for Brimsdown "B."

With reference to elimination of the reheater, the turbine builders' guarantee showed that 79.22 per cent of the ideal cycle efficiency could be attained as against 75.95 per cent and 76.39 per cent of the Brimsdown "A" and "B" reheat cycle efficiencies, respectively. That is, they were able to guarantee a turbine efficiency fractionally higher than that guaranteed for the optimum 1900-psi, 930-F reheat cycle.

The Willesden extension was laid out for an ultimate installation of three 32,000-kw turbine-generators and eight 150,000-lb-per-hr boilers, but initial requirements dictated only two electric generating units and five boilers. It was therefore decided to install two natural-circulation boilers of the Cantieny type (see Fig. 4) supplied by International Combustion Ltd. to serve the first turbine-generator, and three La Mont forced-circulation boilers supplied by John Thompson Water Tube Boilers Ltd. to serve the second turbine-generator. Boiler stop-valve conditions of 1400 psig and 960 F were specified. As in the case of Brimsdown stoker firing was adopted. A diagram of the steam and condensate system for Willesden is given in Fig. 5.

The turbine-generators are straight condensing and each produces 30,000 kw main power and 2000 kw auxiliary power.

Operating Performance

BRIMSDOWN "A."—This went into full service with both Loeffler boilers in December 1938. Although efficiencies of 30 per cent were logged occasionally, this level of performance was dependent upon full boiler availability, since no spare boiler was provided. However, severe low-temperature deposits of a corrosive nature

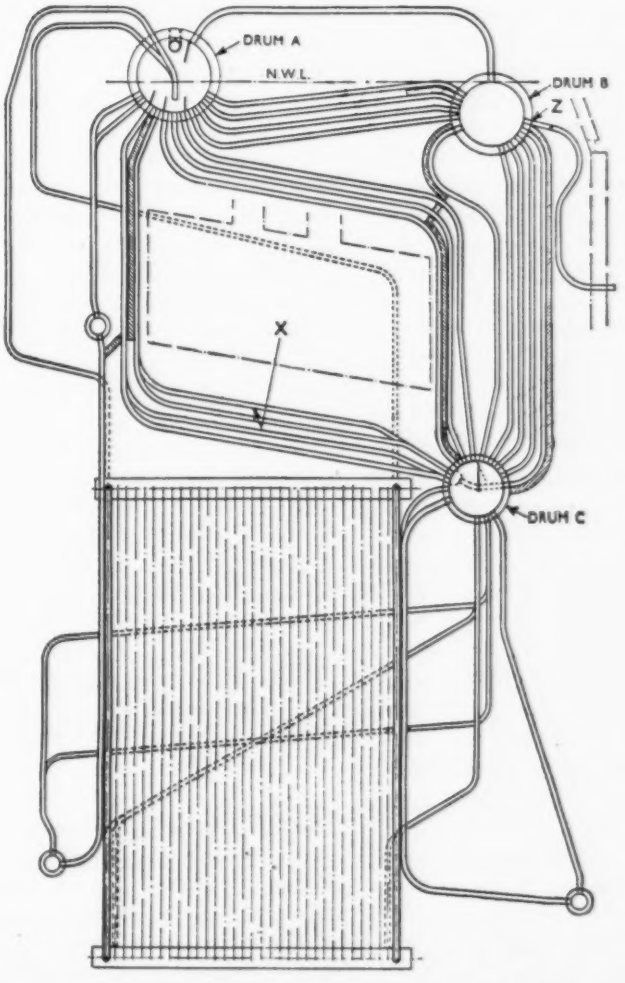


Fig. 4—Circulatory system of the Cantieny boiler

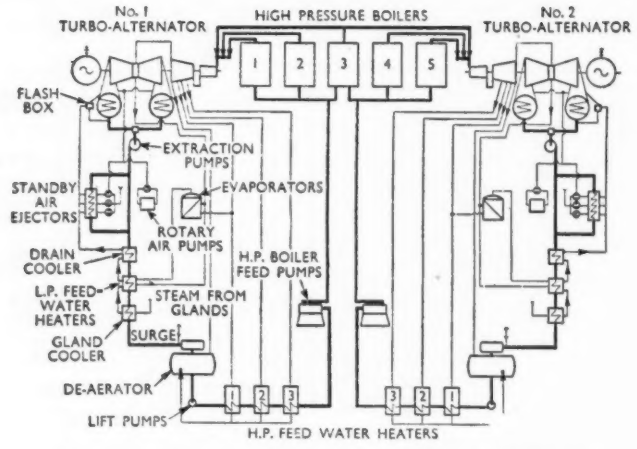


Fig. 5—Steam and condensate system at Willesden

were experienced at an early stage and resulted in choking and corrosion of air-heater elements with frequent boiler outages for cleaning or replacement. An optimum year's run between annual overhauls showed an average thermal efficiency of 26.87 per cent, although for short periods when favorable ratings prevailed a figure of 29 per cent was reached. Moreover, war conditions prevented the use of most suitable coals, yet demanded output at the expense of efficiency.

BRIMSDOWN "B."—It was not until August 1943 that the first Loeffler boiler at this station became available for service. Early operation brought to light a discrepancy in heating surface distribution between the convection superheater and the gas reheater. This necessitated redesign of these components, but load demands did not permit withdrawal of this unit from service until September 1945. The second boiler had already been changed in this respect and from January 1946 on both units have been operated up to design capacity. During 1946, at an average load factor of 37.9 per cent the overall thermal gross efficiency was 27.29 per cent.

WILLESDEN.—The first turbine-generator at this plant, together with one of the La Mont boilers, was placed in service in July 1943 and was operated at half load pending commissioning of the second boiler in May 1944. In August of that year the second turbine-generator and its boilers were in service. For the calendar year 1945 the station as a whole, including the low-pressure plant, showed an average thermal efficiency of 26.53 per cent on the basis of kilowatts generated and 24.57 on a "send out basis." For the high-pressure part of the plant the average thermal efficiency was 27.42 per cent with an average load factor of 33.17 per cent. For 1946 the corresponding figures were 27.12 and 40.76. During the months of March and April 1947 this station, as a whole, ranked first in order of merit for overall efficiency among those in southeast England with efficiencies of 28.22 and 25.58 per cent gross, or 26.40 and 26.88 per cent net.

Operating Difficulties at Brimsdown

Although availability of the 2000-psi plant was much reduced in the early stage through deposits on heating surfaces and corrosion of air preheater elements, these phenomena were not inherently associated with high steam pressure. In fact, the average period of boiler operation between outages for preheater washing or element renewal was 600 hr. Finally, increased availability was attained by changing the air preheater arrangement from contraflow to parallel flow, the effect being to raise the plate temperature to a point where acid deposition took place at a greatly reduced rate. Thereafter deposition on economizer surfaces imposed a limit on hours of continuous service and it became necessary to remove certain of the tube banks to facilitate access for cleaning. Both of these measures entailed higher stack temperatures with consequent reduction in boiler efficiency.

Research during this period established the efficacy, in inhibiting acid formation, of the injection into the gas passes of various dusts, particularly dusts containing zinc oxides. It was also found that injection of a comparatively small quantity of the dust caught by electrostatic precipitators in a pulverized-coal-fired plant had the immediate effect of reducing the dew point of the flue gases to the normal figure associated with acid-free conditions.

The steam-circulating pumps for the Loeffler boilers, despite some early misgivings, proved most satisfactory and only one instance of trouble was reported, but this did not prove serious.

In general, the 2000-lb Loeffler boilers have been safer than some conventional designs operating at lower pressures. While there were several instances of pinholes developing in superheater tubes, due mostly to impingement of soot-blowing jets, no serious results followed, and in one case of this kind the boiler was continued in operation over the peak load period.

Considerable difficulty was encountered from corrosion of the superheated-steam charging pipes and the nozzles in the evaporator drums—a condition that was finally overcome by refitting with stainless steel charging pipes and nozzles of improved design.

Also, trouble was experienced with superheater supports, despite the employment of heat-resisting alloys. Substitution of a steam-cooled design with intermediate support of heat-resisting steel showed, after a few months, that the central support had failed while the outer steam-cooled supports were in good condition. Accordingly all superheater supports at both stations were changed to the steam-cooled type.

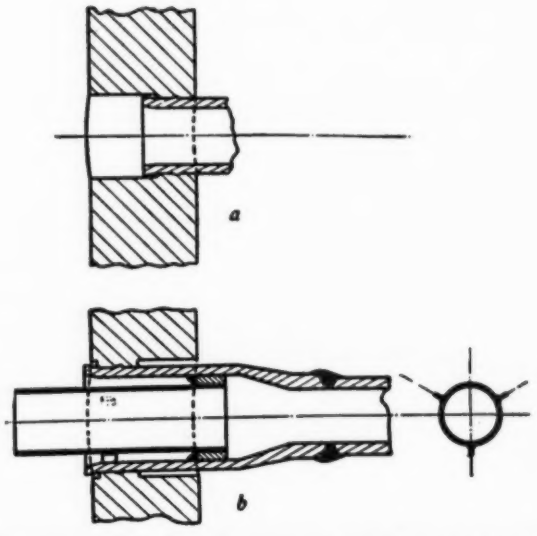


Fig. 6—Expanded joints of economizer tubes in boiler drum

a, original joint; *b*, modified joint.

Operating Difficulties at Willesden

Two early experiences with the natural-circulation boilers concerned, respectively, the circulating system and drum connections. The first was associated with tube failures occurring in both boilers after almost precisely the same number of steaming hours (1500). The location of these failures is indicated at *X*, Fig. 4. These were not attributable to the steam pressure and were corrected by modifications in the baffling within the lower drum *C* as indicated by the dotted lines.

Defective expansion of economizer tube connections *Z* in drum *B* were observed after more than 2000 steaming hours, the design being such that under certain load conditions the economizer would steam, so that there was alternate steam and water at this point. Examination revealed severe local corrosion of the tube seat. The original joint is shown at *a*, Fig. 6 and at *b* is the modified joint with an internal sleeve and counterboring, after the holes had been enlarged to remove the eroded portions. No further trouble from this source was experienced.

The three La Mont boilers exhibited the flexibility and quick steaming abilities expected from the forced-circulation design, but in the early stages they also presented certain operating difficulties. One of these centered around the circulating pumps. Each boiler is served by a motor-driven pump for normal operation and a steam turbine-driven pump for standby, operation of the latter being controlled automatically by the discharge pressure. The pumps are of single-end design and the standing pump is therefore subjected to the full end thrust resulting from the difference between 1400 psi and atmospheric pressure, which amounts to a load of several tons on the thrust bearing. The driving turbines were found incapable of providing adequate starting torque to overcome this end thrust. Therefore, it was necessary to maintain the turbine-driven pumps in operation to the detriment of the cycle efficiency. The difficulty was overcome by providing a hydraulic thrust-relieving device, operating on the admission of steam to the standby driving turbine.

As originally installed the pumps were fitted with glands of the cooling-bush type, but after 1000 hr operation failures were frequent. Good service was obtained as long as the shaft sleeve was in sound condition, but once this became grooved by wear, extrusion of the outermost turn of packing through the retaining ring practically destroyed the efficacy of the gland assembly. Fig. 7 shows the redesigned gland assembly which to date promises satisfactory operation.

FEEDWATER TREATMENT.—During the first few months of operation of the natural-circulation boilers, carryover from the superheaters necessitated periodic washing of the turbine blading. Limiting the total dissolved solids in the feedwater to 150 ppm and the modifications in drum baffling, previously mentioned, appeared to be effective in eliminating carryover.

In the case of the La Mont boilers two forms of incipient oxygen corrosion were observed during the early months of steaming. The first apparently was due to frequent shutting down and standing for appreciable periods partially filled with water while sundry adjustments were being made. This corrosion was localized and indicated irregular pitting, particularly at header plugs and within the drums. The second type of corrosion was evidenced by the presence of magnetic iron oxide fairly generally distributed over the internal heating surfaces.

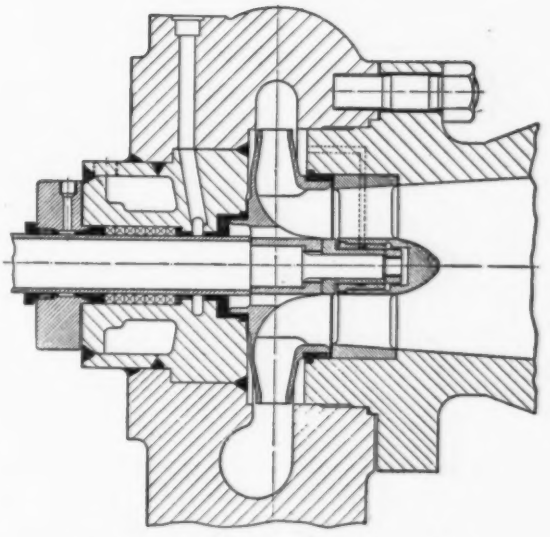


Fig. 7—Redesigned gland assembly

The feedwater treatment adopted for both types of boilers had for its objects zero hardness by maintaining a small concentration of phosphate in solution and zero dissolved oxygen in the boiler water by the introduction of sodium sulphite; also maintenance of an optimum pH of 10 to 11 by introducing trisodium phosphate and disodium hydrogen phosphate in proper proportions. Subsequent inspections have shown satisfactory internal conditions.

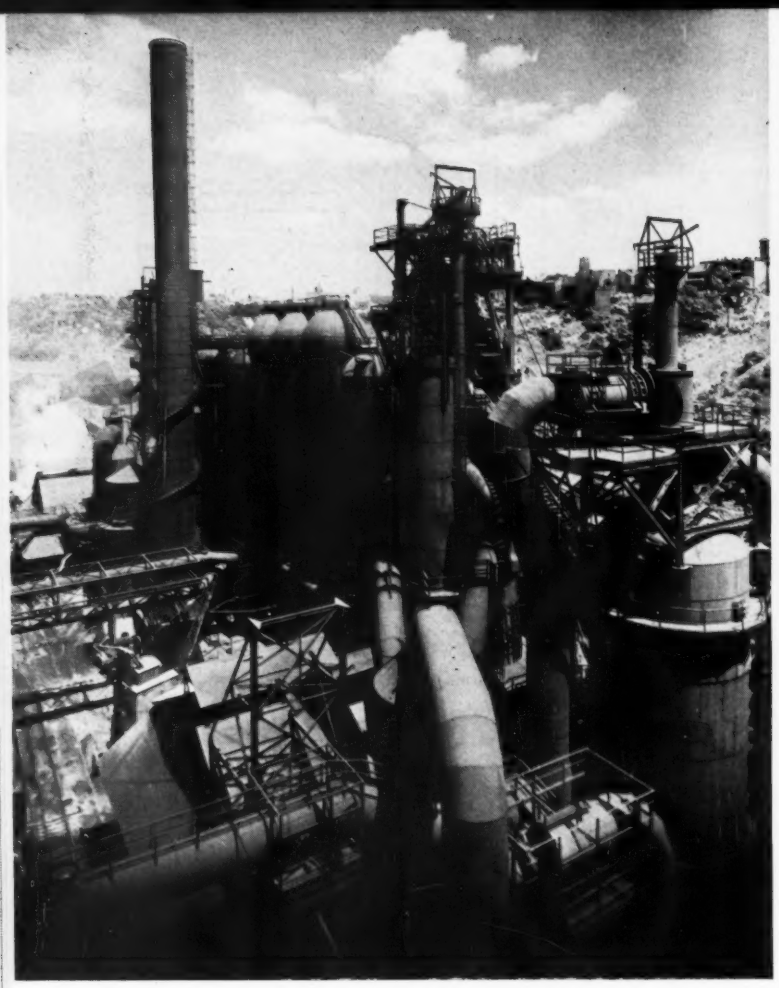
Sundry boiler plant modifications have included conversion of the soot blowers to remote electrically controlled sequence operation and the installation of electrically assisted safety valves to cut down leakage.

Comparative 8-hr boiler tests at Willesden, with feedwater averaging about 360 F, showed net overall efficiencies under normal load of 86.51 per cent for the natural circulation boiler tested and 86.33 for the forced-circulation boiler. Under maximum continuous load the respective efficiencies were 86.27 and 85.15 per cent.

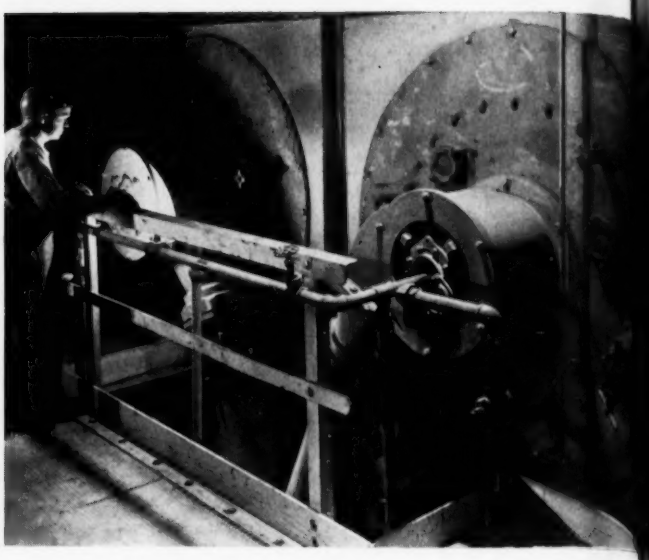
Conclusions

The performance figures at Willesden show that the 1300-psi, 950-F cycle yields equal or superior economy in operation to that at Brimsdown which, with the absence of the complication of steam reheating, commends this cycle as the optimum.

The Company's experience further suggests that adoption of generous boiler ratings, affording ample continuous maximum output capacity, is a prime essential, with attention in the design stages to such practical points as ready access, facilities for cleaning external heating surfaces, and careful planning of soot blower equipment. Furnace design should be such as to provide a gas outlet temperature ahead of the convection surfaces well below the ash-fusion temperature. Boiler plant availability comparable with that of the turbine-generator permits the attainment of high efficiency in operation through adoption of the unit system of one boiler per turbine. This implies large steam generating units which, in turn, entail pulverized coal firing.



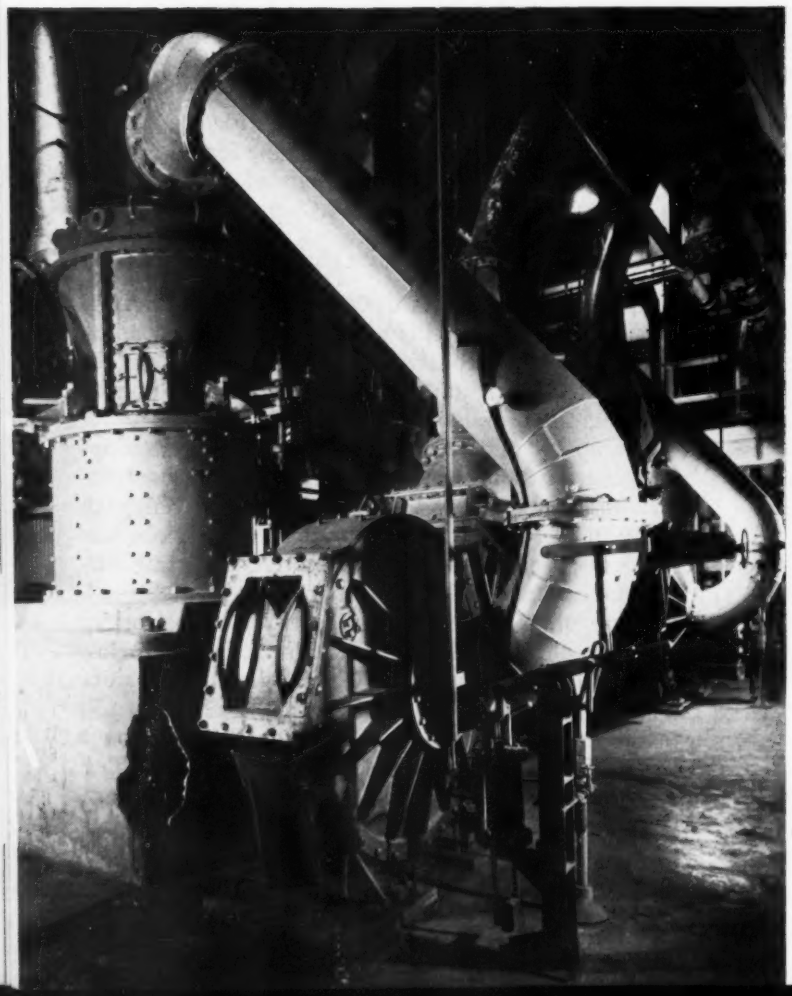
View of blast furnace from boiler house



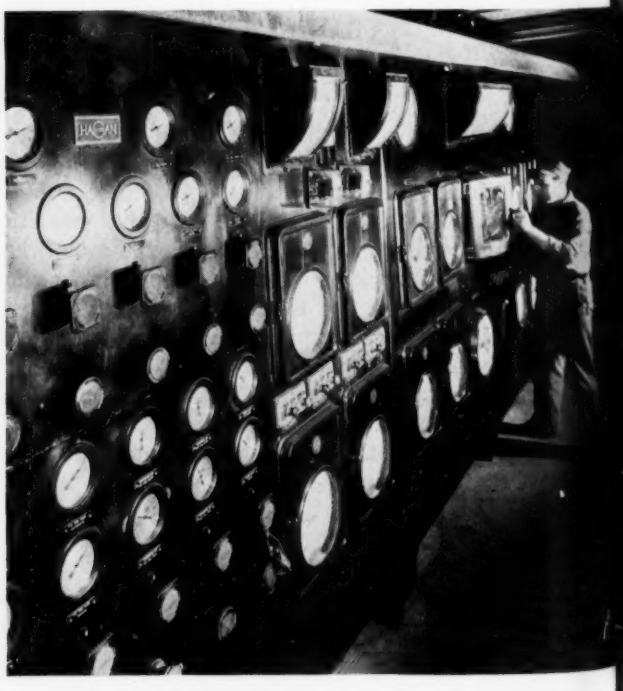
Boiler front showing two of the four turbulent-type burner

More Power for St

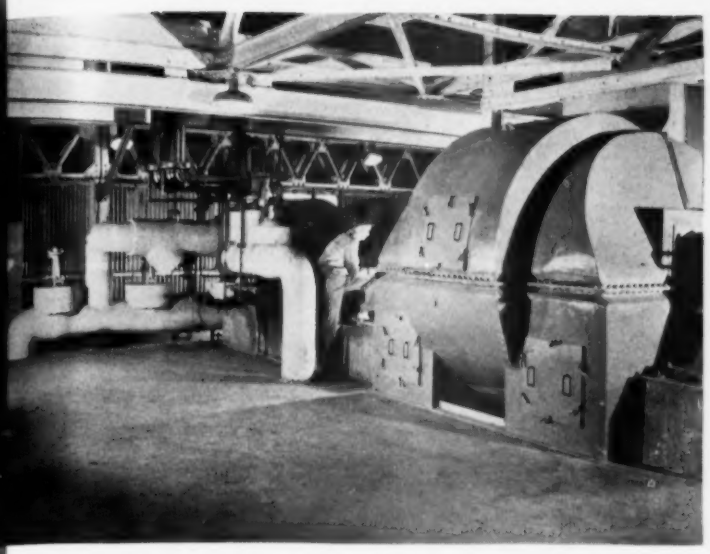
These views show a recent extension of the boiler plant serving the Eliza Furnace of Jones & Laughlin Steel Corp. It consists of a 220,000-lb per hr two-drum C.E. steam generator fired with pulverized coal by turbulent burners supplied by two bowl mills. Steam conditions 430 psi, 725 F at the superheater outlet. Together with five earlier gas- and pulverized-coal-fired units, the



C. E. Raymond bowl mills



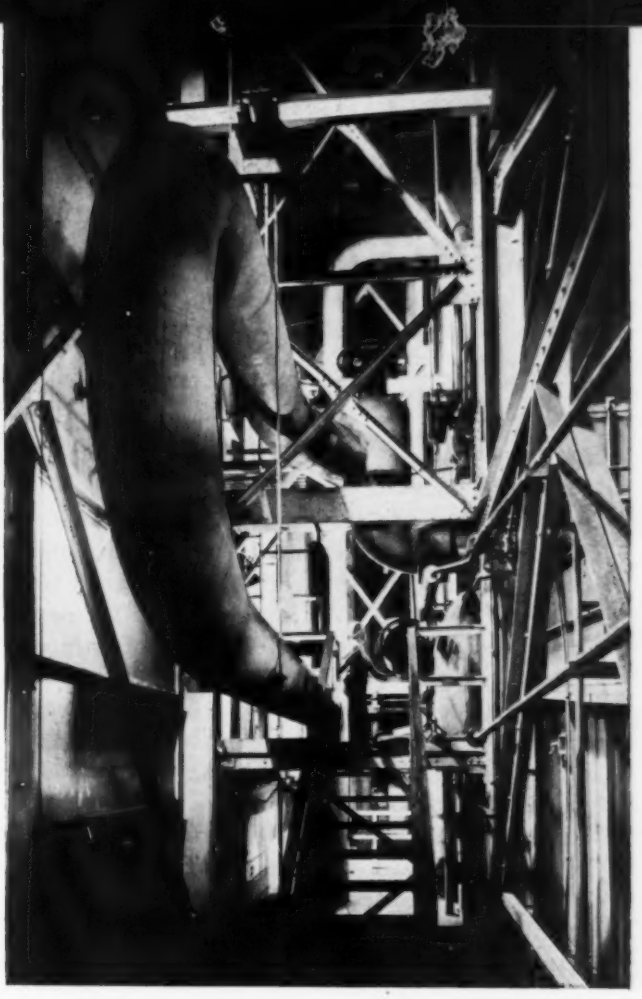
Boiler control panel with Hagan combustion control and Bailey recording instruments



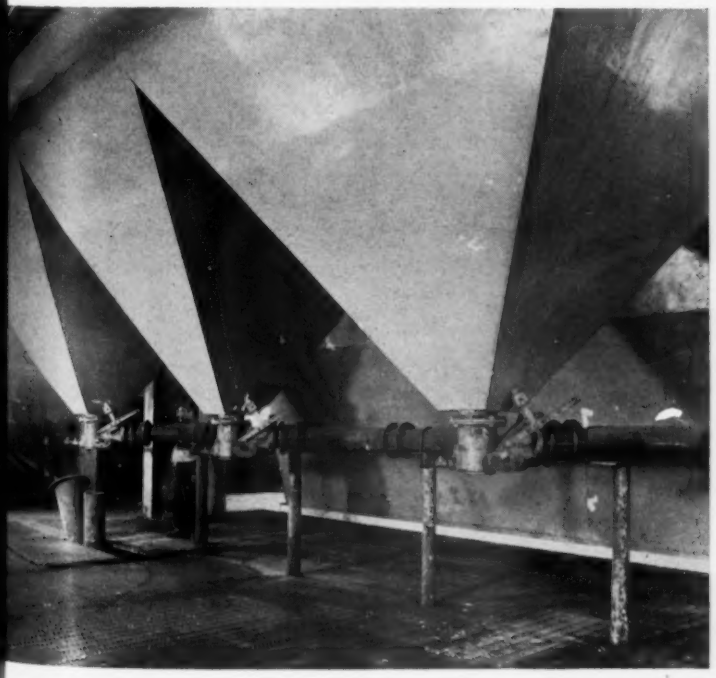
Turbine-driven American Blower induced-draft fan

Steel-Making

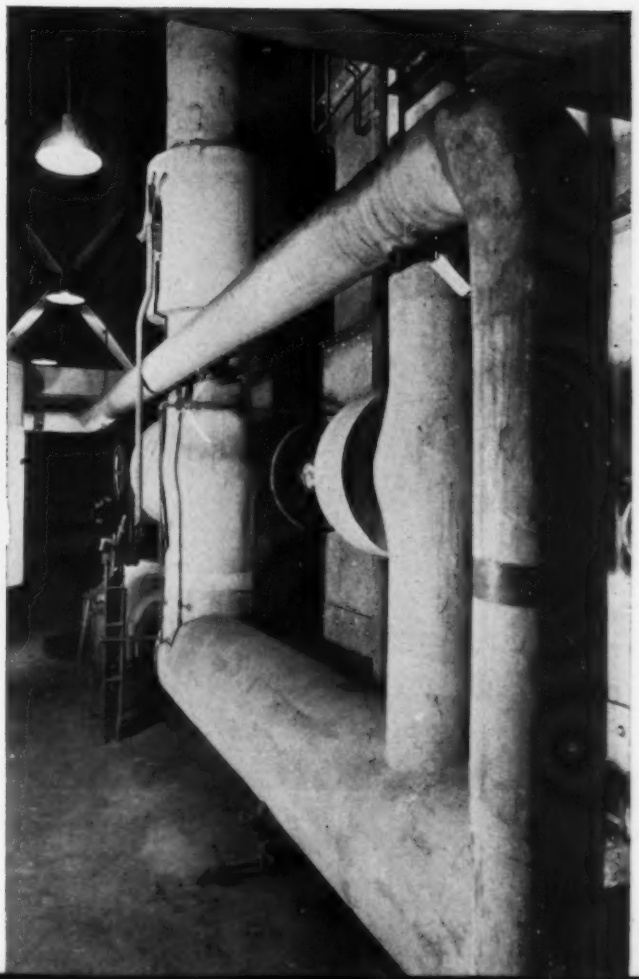
boiler house supplies from 1,000,000 to 1,200,000 lb of steam per hour to four turbine-generators, as well as turbo-blowers. The remainder, at reduced pressure, combines with steam from low-pressure boilers to supply other mill services. We are indebted to Dravo Corp., the contractor, for these photographs.



Top of boiler showing end of steam drum, non-return valve and expansion bend in main steam outlet



Dust-collecting hoppers with Allen-Sherman-Hoff dust valves



Main steam header and connections to boiler, with blowoff tank in rear

Early Developments in Pulverized-Coal Firing—Part 3, The Transportation Field

By C. G. R. HUMPHREYS
Research Dept., Combustion Engineering Co.

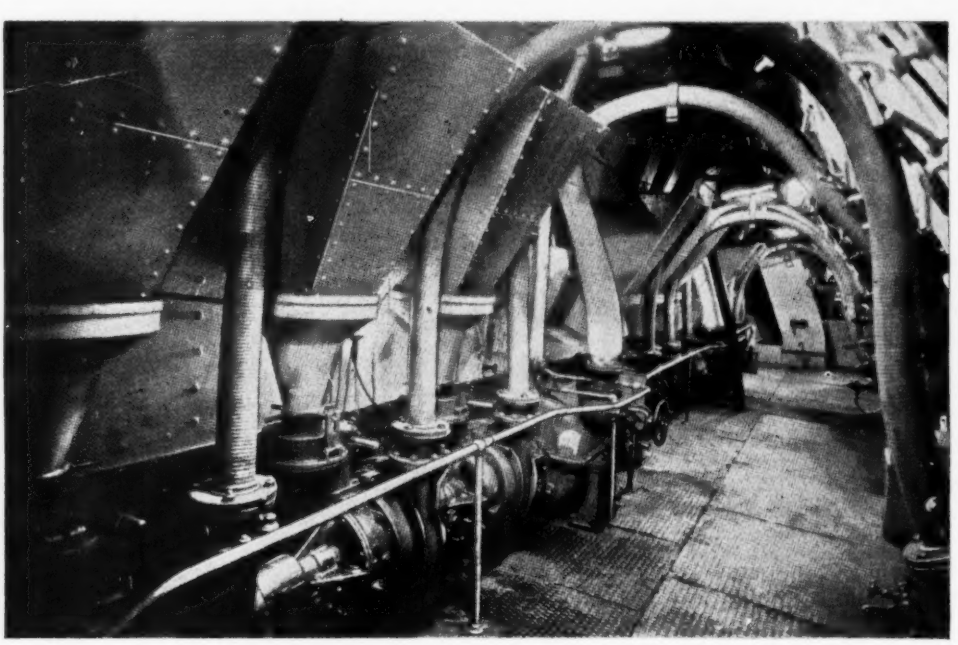
In this concluding article of the series are described numerous attempts, during the '20's, to apply pulverized coal firing to the marine field. A considerable number of vessels were so equipped, but inadequate furnace volume, coal distribution and coal storage proved handicaps. A few years earlier, there was considerable activity, both here and abroad, in the application of pulverized coal to locomotive firing, but this subsided shortly after World War I. With the recent further development of the gas turbine experiments are now being conducted toward applying this type of prime mover, fired by pulverized coal, to the locomotive field.

In Part I (September issue) were mentioned extensive tests on Whelpley and Storer pulverized coal equipment, performed for the U. S. Navy under direction of Chief Engineer B. F. Isherwood, in 1868. However, it was not until half a century later that the *U.S.S. Gem*, Scout Patrol No. 41, was converted to pulverized coal firing and became the first United States ship to be so equipped for ocean-going service. This was a wartime experiment, the vessel being equipped with two 1100-hp Normand boilers. Coal was pulverized ashore and placed on board in bags. It was mentioned that speeds of 17½ knots were sustained without smoke, and the performance was claimed to have been generally better than with oil firing.

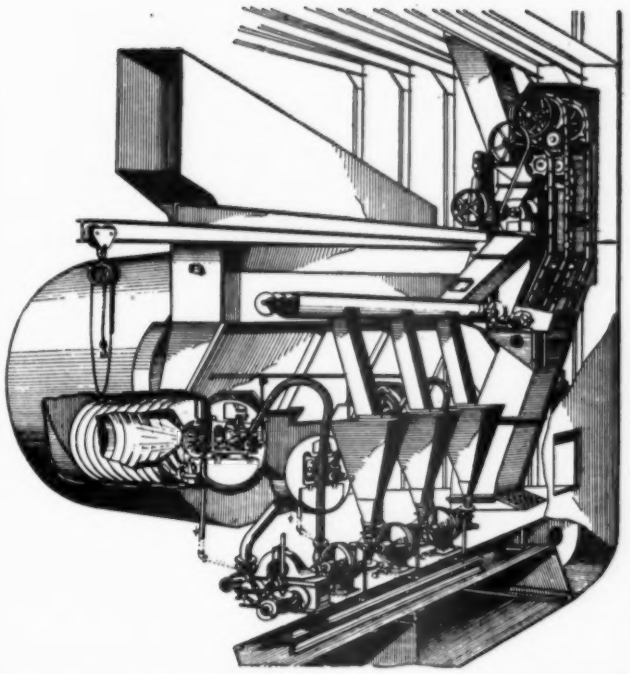
It was in 1915 that a British ship, the *H.M.A.S. Skylark*, was operated with pulverized coal firing one boiler. This vessel plied between Oceanian ports throughout World War I with pulverized coal being stored in sealed bunkers. Special precautions were taken and inert gases from the smoke stack were used to fill the space at the top of the bunkers as their fuel contents diminished.

In 1921 cooperative tests were run by the U. S. Shipping Board and U. S. Bureau of Mines at Erie, Pa., and at Chester, Pa. Here Scotch marine boilers were set up ashore, and straight-shot, stream-flow firing was used with stationary settings, but the limitations of furnace volume and flame lengths brought these endeavors to nothing and they were abandoned.

In 1925 fuel oil costs became high and a Fuel Conservation Committee was set up by the U. S. Shipping Board to study the problem of reducing fuel costs. Attention was directed toward the substitution of pul-



Firing aisle of the "West Alsek"



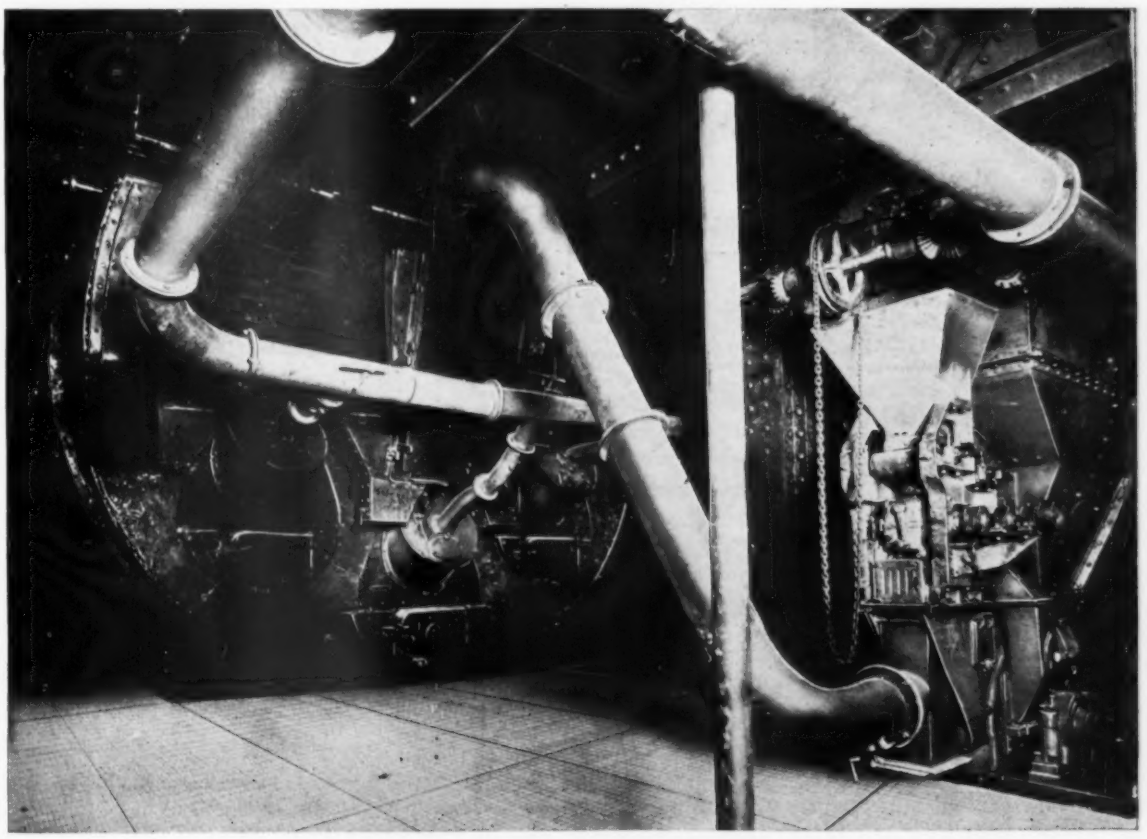
Perspective drawing of West Alsek installation (from *The Marine Engineer and Motorship Builder*, September 1929)

verized coal for oil and this led to a program of experimental work with the cooperation of the Navy at the Fuel Oil Testing Laboratory of the Philadelphia Navy Yard. A three-furnace Scotch marine boiler was set up and tests were conducted with a high-speed pulverizer. This was followed by tests with a single slow-speed ball mill, firing all three furnaces. The results were sufficiently encouraging to warrant a similar conversion installation on the Shipping Board freighter *Mercer* which had three oil-fired Scotch boilers. Two of these boilers were at first converted to pulverized coal firing with one Kennedy Van Saun ball mill delivering coal to three Peabody turbulent-type, inside-mix burners for each boiler. The furnaces had refractory at the front.

First to Cross Atlantic

Described in 1928 as the first commercially successful pulverized-coal-fired vessel to cross the Atlantic, the *Mercer* completed eight such trips to Europe, in addition to voyages to South American and West African ports, covering in all more than 100,000 miles. The principal difficulty encountered with this arrangement on the *Mercer* was a matter of equal distribution of coal to the burners. Also the mills and piping took up considerable space. The discharge of cinders and fly ash from the stack did not impose a serious problem for a freighter, according to Carl Jefferson, chairman of the Committee, in a paper before the Institute of Fuel, London, but such deposits as fell on deck might have proved objectionable for a passenger vessel.

Concurrently with some of the Philadelphia investigations, tests were conducted at Bayonne, N. J., on a B. & W. marine type boiler fired with a slow-speed, Fuller-Bonnot, ball-type pulverizer and a modified Lodi burner. The results of these tests were described in a paper before the Society of Naval Architects and Marine Engineers in 1927. The Bayonne mill and burners



Boiler room of the "Berwindlea"

were later transferred to the Philadelphia Navy Yard and tested with the Scotch boiler.

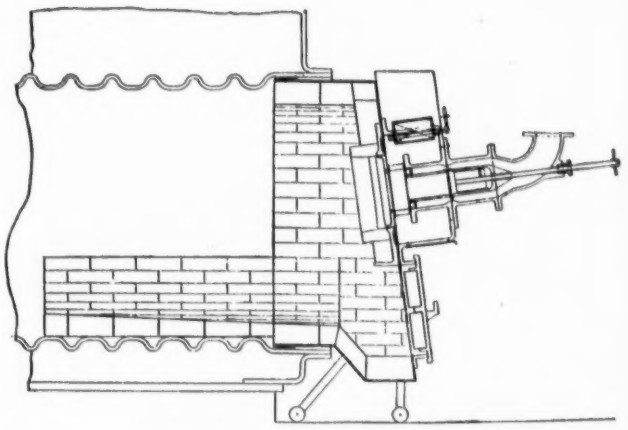
The next series of tests at the Navy Yard was conducted in cooperation with Todd Shipyards Corp., which had been experimenting with pulverized coal. The equipment consisted of one small high-speed, turbine-driven Erie City pulverizer for each burner, thus eliminating the distribution problem. The results led to installation of this system on the Shipping Board freighter *West Alsek*. Here a steam-driven crusher fed coal to an athwartship screw conveyor immediately over the mills which were arranged so that the three for each boiler were driven by a single shaft.

Also, the steamship *Lorain Cross*, a vessel with three Scotch boilers, was converted to the Todd system using three triplex mills.

Further tests at Philadelphia with the Fuller-Bonnot mill and modified Lodi burners led to an installation on the *Dwight F. Davis*, an inland waterways vessel provided with two water-tube boilers.

Subsequently the colliers *Berwindvale* and *Berwindglen* were built by Bethlehem at Fore River, Mass., especially to burn pulverized coal. The former was equipped with two water-tube boilers and the latter with two Scotch boilers, each vessel fired by the Todd system. The bunkers were arranged so that coal trimmed directly into feeders on the mills, and no hand trimming was necessary. These vessels were in service for many years with this system but the writer understands that the *Berwindglen* was subsequently converted to oil firing.

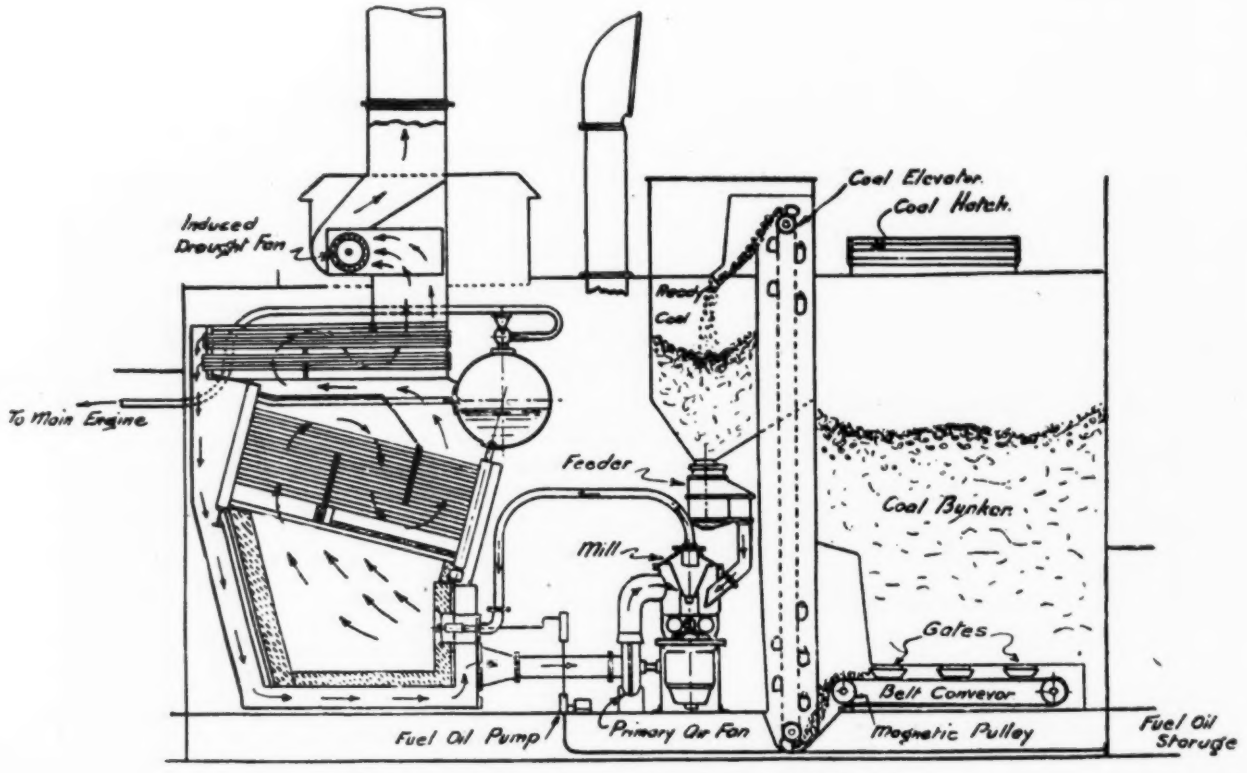
While this development was being carried on in the United States, there was considerable activity abroad, pulverized coal being applied to such vessels as the *Stuartstar*, *Berwindlea*, *Donau* and, in part, to the *Stassfurt* and *Metz*. Of these, the ill-fated *Berwindlea* was the first British vessel specifically designed for pulverized coal firing.



Arrangement of Yarrow system

The following test results of the *Berwindlea* are from *The Marine Engineer and Shipbuilder* (London), September, 1929: "The specific fuel consumption worked out to about 1.28 lb per ihp per hr. The boiler efficiency reached 87 per cent with a furnace temperature of 2700 F. The temperature of the primary air was 520 F and that of the main secondary air about 475 F. The smoke box temperature was about 780 F, the funnel temperature 325 F, and the air pressure at the furnace fronts about 2½ in. Throughout the trials the pulverized-fuel equipment operated with entire satisfaction, while the temperature of the boiler room was commendably low."

The *Amarapoora* was equipped with half its boiler room fired by pulverized coal using a special low-head,



Equipment as employed on the "Dwight F. Davis"

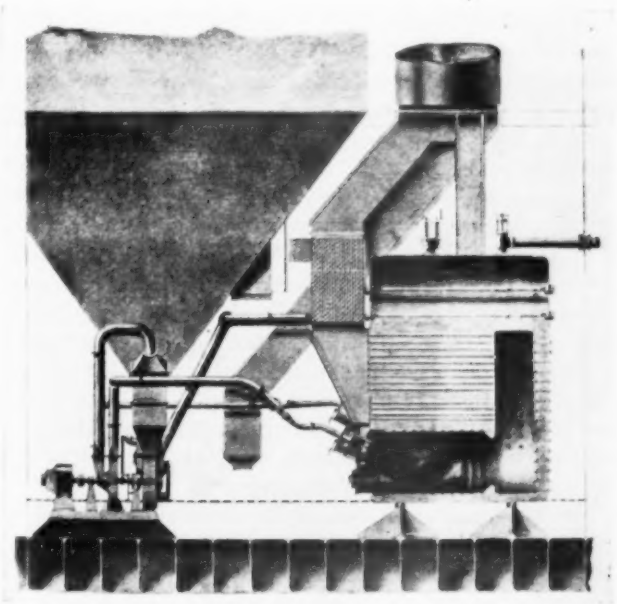
TABLE 1—MARINE PULVERIZED-COAL INSTALLATIONS

Name	Owner	Gross Tonnage	Boilers	Type Firing	
Mercer	U. S. Shipping Board	6219	3 S.E. Scotch	.....	1927
Stuartstar	Blue Star Line	10646	2 S.E. Scotch 2 D.E. Scotch	Clarke, Chapman	1928
Hororata	New Zealand Shipping Co.	11243	6 S.E. Scotch	Brand	1928/30
Linzan	Dominion Shipping Co.	4677	3 S.E. Scotch	.....	1928
Lorain	.....	9759 D.W.	3 S.E. Scotch	Todd	...
Berwindlea	Berwindmoor S.S. Co.	7500 D.W.	2 S.E. Scotch	Clarke, Chapman	1929*
Berwindvale	Wilmore Shipping Co.	7500 D.W.	2 water tube	Todd	1929*
Berwindglen	Wilmore Shipping Co.	7500 D.W.	2 S.E. Scotch	Todd	1929*
Amarapoora	P. Henderson & Co.	8012	4 S.E. Scotch	Yarrow	1929
Swiftpool	R. Ropner & Co.	5265 9000 D.W.	2 S.E. Scotch	.....	1929
West Alsek	U. S. Shipping Board	5637	3 S.E. Scotch	Todd	1929
Donau	North German Lloyd	9035	5 S.E. Scotch	Clarke, Chapman	1929
Dwight F. Davis	Inland Waterways Co.	...	2 water tube	.....	1929*
Metz	C. G. Navigation Du Rhin	...	2 S.E. Scotch	Clarke, Chapman	1929*
Musician	T. & J. Harrison	4663	3 S.E. Scotch	Clarke, Chapman	1929
Recorder	T. & J. Harrison	5982	3 S.E. Scotch	Clarke, Chapman	1930*
Incemore	Furness-Withy	9100 D.W.	.....	Todd	
Illinois	Inland Waterways Co.	No details			
Tamaqua	Reading R.R.	No details			
Nagoya Maru	.....	Clarke, Chapman equipment, no other details			
Jahore Maru	.....	Clarke, Chapman equipment, no other details			

* Originally laid out for pulverized coal.

high-speed "Atritor" mill (in America this was the "Atrita" mill), and Yarrow burners and pre-furnaces.

In a paper before the Institute of Fuel, October 1929, Harold E. Yarrow dealt with experimental work carried out by Yarrow & Co. and described briefly this novel burner and pre-furnace which apparently operated well on a trip of the *Amarapoora* from England to Rangoon. He said: "It will be seen that a mixture of coal and air enters by an annular passage which at one place is constructed so as to cause an injector action and thereby reduce the pressure in the inner tube of the burner. The end of this inner tube is at the point where the primary air carrying the pulverized fuel and the secondary air meet. This mixture is whirling rapidly and, consequently, the center of the issuing stream is hollow. Owing to the reduction in pressure in the tube, there is a suction in this hollow which draws back part of the flame from the furnace into the center of the issuing mixture, thereby making the condition of 'burning back' similar to an oil burner. It must be borne in mind that the object of these experiments was to burn the powdered fuel correctly in a given space with a short flame and with a CO_2 content of not less than 14 per cent in the flue gases."



Arrangement of "Resolutor" pulverizer applied to Scotch boiler as used on the "Stuart Star"

Table 1 is a tabulation of pulverized-coal-fired steamship applications from 1927 to 1930, and is believed to be a fair summary of sizable equipments exclusive of small tugs and lighters of which classes there were a few. None of these ships is still fitted for burning pulverized coal, although some served in this capacity with satisfaction for a considerable time. For instance, the builders of the *Berwindlea* lately advised the writer as follows: "Regarding the *Berwindlea* we regret to state that this vessel was wrecked on an island in the Gulf of St. Lawrence in October 1935, after useful service as a collier plying chiefly between Newport News and the West Indies for a period of six years."

Some, such as the *Incemore*, were lost in World War II, and others reverted to, or were converted to, oil firing. Whether oil or coal be used, conversion to the other fuel is not usually difficult.

Early pulverized coal usage, except in the case of its application to steamships, shows clearly to our now enlightened eyes that without fine grinding and fairly complete drying it could hardly have succeeded.

As a Locomotive Fuel

An attempt to use pulverized coal firing on a locomotive was made in 1903 by the Manhattan Elevated Railroad in New York. Its equipment included a pulverizer, blower and steam turbine, but because of coarse grinding and mechanical difficulties the experiment was wholly unsuccessful. The subject was thereafter closed for several years.

About 1914 there were numerous attempts to fire locomotives with pulverized coal and apparently some were successful for yard operations and for short hauls. These are variously reported with little detail, but in many countries the same operating feature existed: coal was delivered to the locomotive tender in the pulverized state and systems of trackside coal preparation and refueling stations were proposed, but apparently this did not come into common usage.

Perhaps the first large size locomotive to use pulverized coal firing was on the New York Central Railroad in 1914. It was equipped for coal preparation in transit; some details of a similar unit are contained in Table 2. Comparable equipment appeared on a Chicago & Northwestern Railway Atlantic-type; also on a Consolidation-

TABLE 2—LOCOMOTIVES USING THE LOPULCO SYSTEM

	New York Central R.R.	Delaware & Hudson R.R.	Central Ry. of Brazil
Class of locomotive	4-6-2	2-8-0	4-6-0
Cylinders	26 × 26 in.	27 × 32 in.	21½ × 28 in.
Driving wheels, diam., in.	69	63	68
Boiler, psi	180	205	175
Total weight, tons	133	146.5	86
Total heating surface, sq ft	3,769.6	3,814	2,151
Nominal grate area, sq ft	56.5	99.8	30
Tractive power, lb	38,980	66,100	28,400
Coal/1000 ton miles, lb.	101.0	221.9	....
Coal/engine mile, lb	161.9	552.9	....
Average mph	21.8	11.7	....
Service	Freight	Freight	....

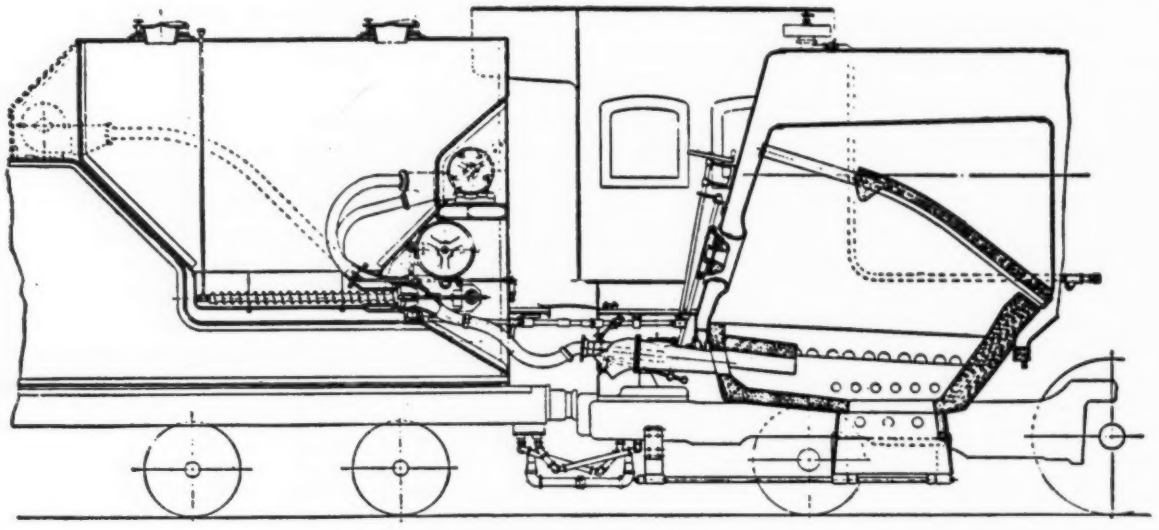
type locomotive described in 1916 as "the largest of this type in the world" for the Delaware and Hudson Railroad. This was built by American Locomotive Company and designed for pulverized coal using the Locomotive Pulverized Fuel Company system. Some data on this application are also noted in Table 2.

In 1916 J. E. Muhlfeld read a paper before the New York Railroad Club in which he predicted that the necessity for conserving the limited supply of oil for other India, Egypt, Assam, Brazil, Chile and in many European nations, chiefly where low-grade coals were available. Frequently mentioned were the Swedish applications using peat powder delivered to the locomotives in a powdered state.

Pulverized Peat Burned in Sweden

A unit was tested in 1916 by Carl Flodin, Stockholm, with a reported efficiency of 75 per cent and a firebox temperature of 1670 F. From 3 tons of air-dried turf, 2 tons of peat powder were obtained. The peat powder contained 12 to 16 per cent moisture; was nonexplosive and long-period storage was possible without danger of spontaneous combustion. The high moisture necessitated a small hand-fired coal grate to ensure continuous ignition of the fuel and evaporation of the moisture.

In a lecture reported in 1924, Dr. P. Wangemann, of the Swedish State Railways, stated: "In America, the difficulties attaching to dust firing have been removed by



Lopulco system applied to locomotive

than locomotive purposes would shortly eliminate it from railway motive power use, and also called attention to the fact that growth of railroad electrification was making inroads into a field where steam had held sway. He remarked that steam locomotives needed higher rates of evaporation, elimination of smoke, soot, cinders, reduction of noise, longer runs and more continuous service. In meeting these conditions, Mr. Muhlfeld claimed that pulverized coal had succeeded because it produced savings of from 15 to 25 per cent as compared with hand firing; it could run as high as 10 per cent in sulphur and 35 per cent in ash and still produce maximum steam-heating capacity; and otherwise unsuitable and unsalable coal or refuse grades might be utilized. Furthermore, firebox temperatures and sustained boiler capacities could be maintained equivalent to and exceeding those obtainable from oil; and the steam locomotive would retain its present relatively low first cost and fixed-charge basis.

For several years following examples such as above mentioned, there appeared frequent references to foreign applications in places often regarded as remote; such as increased drying and finer grinding; in Sweden the opposite path has been followed, and burners for coarser material and a greater percentage of moisture have been resorted to. This contradiction is extremely interesting and instructive. Both methods have been successful. The American method, of higher drying and finer grinding has the advantage of superior technical perfection and, of greater efficiency, but against this there is the greater cost of plant and working in connection with drying and grinding, and the more arduous work of stoking with the coal dust. The Swedish method has the advantage of the more primitive but more reliable firing for working, less expenditure in the treatment of the fuel, better condition for transport of the dried and ground material, much reduced danger of explosions, and, above all, the non-hygroscopic condition of the material itself."

Not only in Sweden was peat powder used but we find references to its applications in 1919 to locomotives in Germany, Austria, Hungary, Switzerland, Italy and Holland.

In Brazil, there were large coal deposits described as easy to mine and transport but so hard to burn that large

importations of coal from Europe and America were necessary. The native coal was generally as follows:

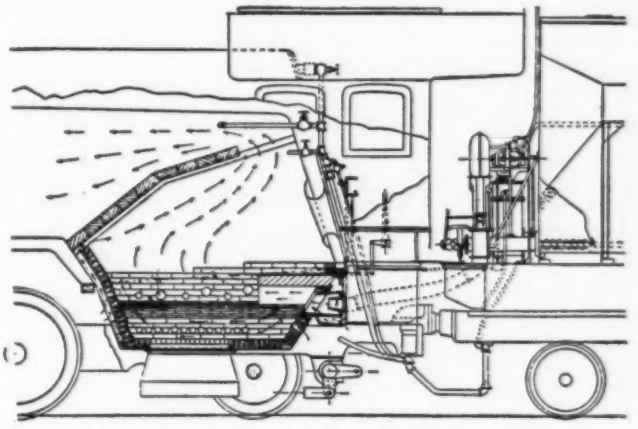
Fixed carbon, 34 to 58 per cent
Volatile matter, 14 to 28 per cent
Moisture, 2 to 8 per cent
Ash, 26 to 30 per cent
Sulphur, 3 to 9 per cent

High volatile and fixed carbon made it a desirable fuel if it could be burned successfully. The Central Railway of Brazil contrived to do this by building a coal preparation plant and ordering twelve locomotives to burn pulverized coal. These were fitted with Lopulco equipment which usually employed three screw feeders, one to a burner; a steam turbine-driven feeder, regulated by varying the turbine speed; and a centrifugal type steam turbo-blower, which delivered primary air at 6 or 8 in. gage to the fuel. Other air supply variations were by hand. Starting operations were reported as simple, and from forty-five to sixty minutes was ordinarily sufficient to get steam pressure up 200 psi from boiler water at 40 F. After firing up, the regulation of the fuel and air supply was adjusted to suit the standing, drifting or working conditions, the stack blower being used only when the locomotive was not using steam.

Lopulco equipment was used on several locomotives here and abroad. One of its few competitors was Fuller Engineering Company whose equipment is also shown here. A noteworthy application of this system was on the Lehigh Valley Railroad where a mixture of 55 per cent anthracite silt and 45 per cent bituminous coal was used. In 1920 a hand-fired locomotive using bituminous coal was matched with this pulverized-coal-fired locomotive and it was reported that the latter showed the following advantages: ash pits were eliminated and no time was lost cleaning fires; cheaper fuel was used satisfactorily; and it was found necessary to load coal only once per round trip, compared to twice with hand firing.

The writer recalls a dusty journey in 1929 on a fast train of the German State Railway using the Stug system of pulverized coal feed and firing here shown.

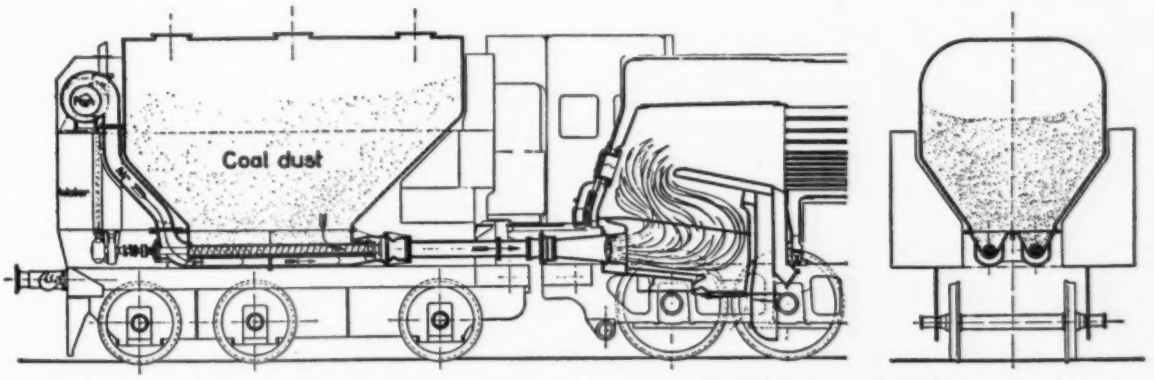
In 1937, the Borsig Locomotive Works in Germany developed a new streamlined, high-speed, pulverized-coal-fired locomotive with driving wheels over $7\frac{1}{2}$ ft. in diameter, a design speed of 109 mph and push-button control of the coal feed.



Fuller system applied to locomotive

The Gas Turbine Locomotive

In America, with the broad applications of diesel-electric locomotives to yard, freight and passenger service, all too frequent unsettled conditions at the coal sources, and electric drives for short city and suburban services, it might seem that pulverized coal is now quite outmoded. But one bright spark remains which may at length restore pulverized coal usage to the field of locomotive transportation. This is its application to the firing of gas-turbine locomotives, which has been under development by the Locomotive Development Committee of Bituminous Coal Research, Inc., for several years.



Application of German Stug system to locomotive (from A.S.M.E. paper by R. Roosen, 1930)

Nevertheless, pulverized coal usage in America practically ceased soon after World War I when the railroads reverted to private ownership. Also its use in Canada and South America disappeared.

Not so, however, in Germany and some other European countries where cheap lignites were abundant.

In an address before the National Coal Association, October 5, 1948, C. K. Steins outlined briefly recent work on this project and pointed out that run-of-mine coal will be bunkered and dried before crushing and

grinding so that a large percentage passes through 325 mesh. This will next be impinged at high pressure and velocity against a highly erosion-resistant material and thus become a truly impalpable powder. This final product, if produced economically, will be burned in combustors to supply gas to the turbine. He stated: "It is interesting to compare this combustion problem with its heat release of a million and a half Btu per cubic foot per hour with the heat release in the firebox of a modern pulverized-coal central station boiler where the heat release is in the order of 30,000 Btu per cubic foot per hour. Much hard work has been done and remains to be done before this completely new type of railroad motive power is on the rails."

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EQUIPMENT SALES

as reported by equipment manufacturers to the Department of Commerce, Bureau of the Census

This will be the last monthly report issued by the Department of Commerce, showing the Stationary Power Boiler and Marine Boiler Sales on a monthly basis. Future sales will be shown on an annual basis.

Boiler Sales

Stationary Power Boilers

	1948 Water Tube		1947 Water Tube		1948 Fire Tube		1947 Fire Tube	
	No.	Sq Ft*	No.	Sq Ft*	No.	Sq Ft*	No.	Sq Ft*
Jan.....	134	686,680	160	1,062,949	76	119,047	106	106,788
Feb.....	154	935,431	149	969,541	61	81,330	90	99,267
Mar.....	173	1,062,816	167	851,697	65	91,241	80	109,984
Apr.....	189†	1,170,956†	176	1,027,313	87	112,170	71	102,315
May.....	139	842,301	150	988,794	67	89,450	56	73,821
June.....	128	686,224	176	1,543,519	50	67,255	49	78,491
Jan.–June, incl.....	917	5,384,408	978	6,443,813	408	560,493	452	570,666

* Includes water wall heating surface. † Revised.

Total steam generating capacity of water tube boilers during the period Jan. to June (incl.) 1948, 56,213,000 lb per hr; in 1947, 73,432,000 lb per hr.

Marine Boiler Sales

	1948 Water Tube		1947 Water Tube		1948 Scotch		1947 Scotch	
	No.	Sq Ft*	No.	Sq Ft*	No.	Sq Ft	No.	Sq Ft
Jan.....	—	—	2	7,724	—	—	—	—
Feb.....	17	90,945	2	1,423	—	—	—	—
Mar.....	30	204,262	5	22,232	—	—	—	—
Apr.....	12	76,228	11	6,801	1	990	—	—
May.....	5	34,637	—	—	—	—	—	—
June.....	12	75,140	1	688	—	—	1	1,290
Jan.–June, incl.....	76	481,212	21	38,868	1	990	1	1,290

* Includes water wall heating surface.

Total steam generating capacity of water tube boilers sold in the period Jan. to June (incl.) 1948, 5,087,000 lb per hr; in 1947, 729,000 lb per hr.

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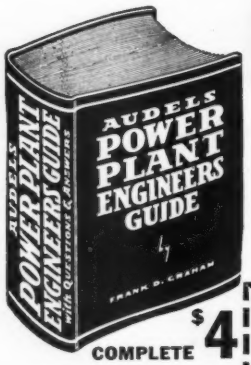

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SYNTHETIC FUELS

By FRANK A. HOWARD
Consulting Engineer, New York City

In the following address before the National Coal Association on October 5 the author describes and traces the history of the hydrogenation and the hydrocarbon synthesis processes for producing oil from coal, including their present status, and discusses the economics involved. He suggests methods for laying the foundation of a synthetic fuel industry in this country.

THE synthesis of oil from coal on an industrial scale began in Germany in 1930. The process was called "Destructive Hydrogenation," or, for short, "Hydrogenation." The sponsor was the I. G. Farben, A.-G., which was the strongest industrial concern in Germany. By this hydrogenation process a small part of the coal is used to make hydrogen gas and the balance of the coal is treated with this gas at high temperatures and pressures. Operations continued on a slowly increasing scale until the war and were then very rapidly expanded. At the end of the war, there was a production of oil from coal by this method in Central Europe of 63,000 bbl per day and the plant investment was equivalent to about $750,000,000, a substantial part of which was private capital.

Operations of this same process on both coal and coal tar were begun in England by Imperial Chemical Industries, the strongest English chemical unit, in 1934. The original plant had a capacity of about 3000 bbl per day of oil, and cost something in the neighborhood of $25,000,000, all of which was private capital. This plant has continued in operation up to the present time with some improvement but without enlargement. Cost of production of gasoline from coal in these German and English plants between 1930 and 1945 was in the neighborhood of 25 cents per United States gallon and, therefore, both countries had to heavily subsidize the production since the price of imported gasoline was in the neighborhood of 7 to 10 cents per gallon in tank steamers at Atlantic ports. The German subsidy arrangements were effective enough to cause the industry to grow but are too complex for review here. The English arrangement was simple. Imported oil products carried an excise tax of 15 cents per U. S. gallon from which the synthetic production was exempted. This was enough to keep the original English plant alive but not enough to encourage any further construction. Because there was a better profit in the hydrogenation of coal tar than coal itself, and also a higher output of gasoline and diesel oil, the plant eventually operated only on tar received from byproduct coke plants all over England and that is its present status.

The world rights for the hydrogenation process outside of Germany were bought by Standard Oil (New Jersey) in 1929 for $35,000,000 in a settlement which also gave Standard distribution rights for the synthetic gasoline made from coal in Germany. In acquiring the hydrogenation process, the oil people had three business objectives in mind.

First, they wanted to use various modifications of the process to get better yields of higher quality refined products from crude petroleum.

Second, they thought they saw the time coming when there would not be enough crude oil to meet demand, and even in the United States it would be necessary for them to turn to coal as a source of oil.

Third, they saw certain world-wide tendencies, similar to those which had led Germany and England to subsidize national synthetic oil industries, and they wished to protect their oil exporting business and their oil distribution investments in foreign countries by being able to lead instead of merely to resist the scientific advances which made possible these government-protected synthetic industries.

The combined influence of these three business factors was so strong that by 1931 about 80 per cent of the world's oil industry, United States and foreign, had joined Standard Oil Company (New Jersey) by taking participations in or licenses for the hydrogenation process.

The original cooperative arrangement in the oil industry for the handling of the hydrogenation development in the United States was voluntarily dissolved after World War II, but virtually the entire oil industry of the country has a good understanding of the coal hydrogenation process, its present status and its possibilities. None of the United States oil companies has actually carried out coal hydrogenation operations here except on a laboratory scale, but several of them have used the process commercially on special oil-refining problems, and there are some engineering and contracting companies with experience in hydrogenation plant design and erection.

The Bureau of Mines has, since the end of the war, assumed the responsibility of serving as a central source in the United States for technical data on the coal hydrogenation process. It has very complete information on the European operations and it is also carrying forward

research and experimental work of its own, including the building of a demonstration unit.

Hydrocarbon Synthesis

In addition to hydrogenation, there is another method of producing oil from coal. This is the Fischer-Tropsche or "Hydrocarbon Synthesis" process which also originated in Germany. For this process, the coal must first be converted entirely into gas by heating with steam. The gas is then passed through catalyst beds where it changes into gasoline and diesel oil. This operation was first industrialized in the early 1930's by a group of German coal, steel and chemical companies, known as the Ruhr-Chemie. They were sound, practical people with large resources and were well able to finance the initial development, but they were not comparable with I. G. Farben in ability to industrialize new chemical processes. Therefore, in attempting to exploit their process in competition with the I. G. hydrogenation process they made very little headway. They did get a few small plants built and sold licenses or options to concerns in South Africa and Japan and also to the Texas Oil Company of the United States. But their process was really only half developed until the I. G. became interested in its possibilities and came into agreement with them some time before the recent war in Europe.

An American syndicate, headed by Standard Oil Company (New Jersey), took over the rights to this process, with the I. G. improvements on it, in 1938 and some research was initiated here in the United States but came to an early stop because of war conditions, and the syndicate dissolved. In Germany, the war caused a rapid expansion of the Fischer-Tropsche operations and at the end of the war there was a production of 11,000 bbl of gasoline and diesel oil per day in Central Europe by this hydrocarbon synthesis operation. The investment was probably around $100,000,000, most of which was government capital. The members of the American syndicate referred to had very complete pre-war data on the design and operation of the German plants, and following the end of the war the Bureau of Mines' representatives visited these plants and brought back their own reports which are now available to all. The hydrocarbon synthesis process must, therefore, be accepted as a second practical process now available for industrial use in the United States to convert coal into oil, although its background of commercial use and experience, both abroad and in the United States, is much smaller than is the background in hydrogenation.

Arguments for Converting Coal to Oil in the United States

As has been indicated by this short review, the record of both Germany and England in using these two industrial processes of making oil from coal shows that both are entirely practical but at pre-war price levels they required and obtained governmental subsidies of at least 15 cents per U. S. gallon. While both developments were initiated by private capital, the large expansion was made only with government money and under the pressure of military necessity. The pre-war commercial interest of the oil industry in these processes arose from a variety of collateral considerations and as a hedge against any eventual oil shortage. Because of ample crude reserves, the oil companies had no immediate commercial interest in producing oil from coal in the U. S.

Since the end of the war, however, some of the same economic and military factors which led Germany and England to support production of oil from coal, and led Italy, Japan, Russia and some other foreign countries to take the first steps toward the same result, have begun to make themselves felt in this country.

Like these less fortunate foreign nations, we have begun to feel some uneasiness about our oil supplies. For the first time in its peace-time history, the American oil industry has had widespread recurrent spot shortages of crude and its products. The public, not fully realizing the temporary nature of the situation, was often worried and sometimes actually inconvenienced.

While the immediate causes of these minor shortages usually involved transportation, back of them was a precarious statistical balance between maximum available current supply and the rapidly mounting current demand. As in many other industries, new facilities were not becoming available fast enough. At the same time the United States lost its traditional position as an exporter with a surplus to sell and became a small net importer of oil products. The forecast for world supply and demand showed that greatly increased supplies of Middle Eastern oil would be soon required to achieve any world statistical balance, and the American oil industry began to pour money and materials into Arabia, the plan being to bring large amounts of Middle East oil to the Mediterranean to supply the Eastern Hemisphere and permit the United States to take Venezuelan oil, now going to Europe, to meet its own deficiency.

The rate of increase of the present small deficiency of oil in the United States is still a matter on which opinion differs widely. It is pretty generally believed, however, that if we limit production from known fields and future discoveries in accordance with present regulations, so as to avoid undue waste of oil or gas and obtain maximum eventual recoveries, our present deficiency of over 100,000 bbl per day will steadily climb, and within 15 yr, or perhaps much less, not only the United States but the Western Hemisphere as a whole will produce less crude oil than it consumes. There will be Middle East oil entering the United States long before that, of course; in fact a small amount has already reached our shores. But this is cross-hauling due to trade conditions. Statistically, we should not need Middle East oil for many years.

In addition to this statistical forecast of increasing shortages in domestic supply, we have to consider the general arguments for conservation. Conservationists not only insist upon the maintenance of current production restrictions which avoid waste, but they also point to our limited total resources in oil, from known fields and probable future fields. These total resources are accepted as at least fifty years supply, but on the other hand, they assert, our coal reserves are comparatively unlimited. Hence the national policy should always favor the use of coal, either as a direct substitute for oil, or as a source of oil.

The last factor, and the one which at the moment may be the most important in influencing Congressional opinion, is a military consideration. The Defense Secretary, the Interior Secretary, and the President have made it perfectly clear that they do not think we are safe, either in the immediate future or the distant future, with our present oil supplies. In the event of war, they think our present national requirement of nearly 6 million barrels

per day would increase by 2 million barrels; and instead of having more crude oil we might have less available for our own needs and also be required to carry part of the European demand. The Middle East supply to England and Western Europe is vulnerable by land, by air and by sea, and the South American supply, either to Europe or to the United States, is also vulnerable to a lesser degree by sea and by air.

These are the principal economic and military arguments for government support of an industry of coal conversion similar to the pre-war German and British industries, but on a much grander scale and on an improved technical foundation, aided, of course, by the additional United States knowledge of the whole broad subject acquired here since World War II. It is unnecessary to say that there are counter arguments available, some of which will be mentioned in attempting to summarize recent developments and current progress. But it would be a mistake to underestimate the force of the foregoing arguments. They involve both long-range and short-range economic and military considerations, and they will be supported by one set of reasons if we have a continued high level of business and full employment and by another set of reasons if there is a recession and unemployment. That was the history of the debate on this issue in foreign countries.

Recent Developments and Current Status

The current oil supply situation in the United States has definitely improved during the present year. Allocation of gasoline during the summer was barely noticeable to the public and it is expected that the same condition will carry through the winter on domestic fuel oil. The new oil discovery in Alberta, following a long succession of failures in Canada, has enhanced the reputation of petroleum geology and created more confidence in the methods used to forecast probable new fields.

But this relief from the slight pressure of a year ago is not yet sufficient to quiet all fears on current supply. The margin is so narrow that such incidents as the oil workers' strike in California could lead to winter shortages. And the basic position remains unchanged. Oil production in the United States will probably fall short of current demand by increasing amounts each year. There is at present no reason to question the forecast that our status from now on will be that of an oil importing nation.

In the international field, developments of the past year contribute more and more to uneasiness over foreign oil supplies. It is quite possible to conclude that if war comes it will be soon, short and decisive. Therefore, the diversion of any of our present resources in men and material to the creation of a multibillion dollar synthetic oil industry, as suggested by the Administration earlier this year, would be a strategic blunder. But this reasoning is not by any means universally accepted. The hypothetical war may be long delayed or it may be a long one requiring an unprecedented use of oil fuel, or it may be indecisive, leaving us with further perils ahead and less foreign oil than we now have available to us to meet them. No one can know the answer to these questions and any forecast made must be that of the government itself, not industry. The last year has shown such deterioration in the European situation as to urgently require such a forecast and the best plan possible to meet it, if, in fact. the forecast and the plan had not been made a year ago,

There has been increased governmental activity and many requests for industrial cooperation on several aspects of the synthetic fuel matter during recent months. At least four Committees are examining the synthetic fuel problem at this time. There is the Industry Advisory Committee of the Bureau of Mines Office of Synthetic Liquid Fuels, the Military Petroleum Advisory Committee, the National Bituminous Coal Council Committee on Synthetic Fuels, and the A. P. I. Committee on Synthetic Fuel. In the meantime, the inadequacy of existing data on the extent, quality and location of coal reserves actually useful for a synthetic industry has been quite generally admitted; and the Army Engineers have taken the first steps toward getting better data in a limited area through a contract with Ford, Bacon & Davis for making such a study.

The Bureau of Mines has also let a contract for a small pilot plant of the hydrocarbon synthesis type to be built at Louisiana, Mo., near the eighty-barrel-per-day-hydrogenation demonstration plant which is under construction there.

On the legislative side, the House Interstate and Foreign Commerce Committee held hearings earlier in the year on the Wolverton Bill which proposed an appropriation of $350,000,000 to the R. F. C. for financing synthetic fuel plants, which plants, if not initiated within a year by private industry, were to be undertaken at once by the government itself. As a result of its hearings, the Wolverton Committee rewrote its original bill to make it considerably more flexible. In substance, however, it remains a government program to finance synthetic oil projects, which, if not initiated by private industry, would be undertaken by the government itself. The Wolverton Bill was reported out of the Commerce Committee and was understood to have good support on both sides of the House. A comparable bill to Mr. Wolverton's was introduced in the Senate by Senator Johnson for Senator McCarran. It is expected that these bills will be presented promptly after the new Congress convenes. Additional bills in both the House and Senate have been introduced providing special income tax advantages for the builders and operators of synthetic fuel plants.

During the late summer recess, Senator Malone, Chairman of the National Resources Economic Subcommittee of the United States Senate Committee on Interior and Insular Affairs, has been active in exploring this subject of synthetic fuel from a government policy standpoint. Public hearings by his special committee have been postponed until January 18. Senator Malone has a very large panel of witnesses from the oil and coal industry to examine and it seems likely that the studies of his Subcommittee will form a basis for new legislative proposals. In an interview by Mr. J. H. Carmichael, petroleum specialist for the *New York Times*, Senator Malone is reported to have outlined a plan for subsidizing a synthetic oil industry by impounding for that purpose the revenue to be collected from an increased import duty on foreign crude oil. The combination of the Wolverton Bill of the House and this reported Senatorial proposal would seem to outline one fairly definite governmental plan for initiating and supporting a limited synthetic fuel industry in the United States.

Conversion Process Compared

It might be in order to look now at the two known coal conversion processes and see what course of development would be most likely to take place if these legislative proposals crystallized. During the war the hydrogenation process and the hydrocarbon synthesis process seemed to be nearly competitive on investment and operating costs under European conditions, with some advantage for hydrogenation. Technical and economic developments seem to have changed this status. Hydrogenation is no longer regarded as at all competitive with hydrocarbon synthesis in the United States. At least this appears to be the opinion of those industrial concerns which have expressed views on the subject. Further confirmation comes from an engineer familiar with current costs of oil synthesis in England. Translating his English figures to American terms would indicate that to support coal hydrogenation in this country would require a subsidy of 18 cents per gallon.

The hydrocarbon synthesis process has, of course, encountered the same rising costs of material and labor which have scaled up hydrogenation estimates, but there have been very important offsetting technical advances in the hydrocarbon synthesis process. It now appears possible that conversion of coal to oil by hydrocarbon synthesis in the United States might *eventually* stand on its own feet if all prospective improvements work out favorably. These prospects are enough to justify several large-scale programs of privately financed research and development work, but are by no means certain enough to invite private investment in commercial operations at the present time. Revolutionary changes in synthesis steps have been completely worked out in this country since the war. The important technical problem as yet not entirely solved is how best to modernize the old art of coal gasification. If governmental action were to force immediate plant construction, there would be no possibility of realizing the great economies of investment and operating costs promised by the various modernization suggestions now being tested.

The most important open question in relation to this oil synthesis matter at the present time, therefore, seems to be how to reconcile the indicated governmental policy of starting at once upon the building of a synthetic fuel industry with the incomplete state of the experimental data on modernized coal gasification processes and also the inadequacy of basic data on coal reserves on which a synthetic fuel industry of size important for defense purposes can be outlined. This latter point is one that has, until quite recently, been ignored.

One solution of both problems is legislation which would result in laying a broad foundation for a synthetic fuel industry under a definite schedule and program. Three lines of work involving expensive engineering and development must be scheduled and carried forward together under some plan of cooperation between industry and government which will actually create the necessary foundation. These three lines of work seem to be: *First*, further technical development and pilot testing of modernized coal gasification. I believe private industry wishes to do this work itself without governmental subsidy, but would be entirely willing to fit its own programs into any overall schedule or timetable proposed by the government. *Second*, the preparation of complete and reliable project plans for large synthesis units at fixed locations, preferably capable of great expansion or duplication by the sponsor of the original plant at the same or other specific locations. The actual cost of engineering work involved in making up these project plans could well be met by government funds under contracts with the industrial units requested to make them. *Third*, the collection of sufficient field engineering and geological data on location, quality and mining conditions of coal reserves and shale reserves suitable for conversion to permit the outlining of a master plan for a great synthetic fuel industry for the nation as a whole. Work of this kind could well be contracted for and supervised by the Army Engineers.

Conclusions

In closing, I wish to make it clear that I consider it to be the sole responsibility of government to decide whether a foundation must now be laid, at government expense, for a national synthetic fuel industry. I have found no one in the coal or oil industries who held a different view. Statements of the President and the Secretaries of Defense and Interior, coupled with the Wolverton Bill of the House and the McCarran Bill before the Senate and the reported plan of Senator Malone, seem to represent the considered judgment and conclusion of these governmental authorities that some foundation should be immediately laid.

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Water Conference Features Precision Control and Debates Deaeration

THE program of the Ninth Annual Water Conference, at Pittsburgh, October 18–20, covered various phases of water treatment, from the standpoints of municipal supply, power boilers and industrial uses. Of particular interest to power engineers was the second afternoon session which was sponsored jointly by the Conference and the Joint Research Committee on Boiler Feed-waters.

This session opened with a statement by T. H. Daugherty concerning the activities during 1947–1948 of the Joint Research Committee on Boiler Feedwaters, the Executive Committee of which comprises W. C. Schroeder, Chairman; S. F. Whirl, Vice-Chairman; and R. W. Senniff and T. H. Daugherty as alternate vice-chairmen.

A paper, "The Precision Control of Boiler Water Conditions," was presented by Dr. R. E. Hall, Director of the Hall Laboratories. Its thesis was the constantly changing pattern in water-conditioning technology, pointing out the many factors responsible for these changes, and the present state of progress, particularly in this country, in this important phase of power generation. In a lucid, interesting style, Dr. Hall carried the audience chronologically from the early 'twenties, when 400 psi was considered a high operating pressure, through the 'thirties, when the pattern for water treatment underwent marked changes to keep pace with the trends in operating practice, to the 'forties and the present time. He concluded with a statement of the factors that have led to recognition of the importance of small differences where boiler water is concerned.

Even in the early 'twenties it was recognized, as now, that the feedwater should be as nearly pure as distilled water to avoid trouble. But beyond this, there was no clear-cut pattern for water control. Some contended that where makeup was necessary, preliminary softening, without supplementary treatment, was all that was required; others held that direct treatment of the boiler water with commercial chemicals was the answer. But, for lack of experimental data, satisfactory criteria for conditions in the boiler could not be established.

Joint Investigations Begun

It was during this period that various agencies—the ASME; the Detroit Edison Company, in conjunction with the University of Michigan; the University of Illinois; the Hagan Corporation, in conjunction with the Bureau of Mines; and Mellon Institute in conjunction with the Elliott Company—undertook research investigations of many factors related to the overall problem. The principal projects dealt with the physical chemistry of boiler waters, the embrittlement of boiler steel, the deaeration of boiler feedwater, and water treatment practice evolved from the status of patent medicine quackery to a precise, scientific subject.

During the 'thirties the ASME Subcommittee 6, under the chairmanship of the late J. H. Walker, undertook to investigate intensively the embrittlement of boilers, and ASTM Committee D-19, under the chairmanship of Max Hecht, began to assemble and digest the facts on water conditioning as they became available, and to devise acceptable methods of testing water.

During the early 'forties Purdue University and Detroit Edison Company contributed heavily to knowledge of the effect of high-temperature steam on plain carbon and alloy steels, thus keeping pace with the trend toward high temperatures and pressures. The factors influencing heat transmission in boiler tubing at pressures from 550 to 3300 psi were studied by the research staff of the Consolidated Edison Company, and localized steam blanketing was demonstrated experimentally.

Crystallographic Studies

It was also during this period that greater attention was paid to determining the crystallographic characteristics of boiler scales and sludges, by means of the polarizing microscope and X-ray diffraction apparatus, thus supplementing ordinary chemical analyses.

Lastly, in the 'forties the Edison Electric Institute, in conjunction with the Association of Edison Illuminating Companies and the boiler and turbine manufacturers initiated an extensive investigation of all phases of steam contamination.

Dr. Hall then proceeded to show how the facts already established by this broad front of investigation have been used to formulate a precision control for boiler-water conditions.

EMBRITTLEMENT—This phenomenon was classified as *Classical* and *Tube* embrittlement by Dr. Hall, and he emphasized that the reaction $3Fe + 4H_2O = Fe_3O_4 + 4H_2$ was the basic mechanism of each. The *classical* type was discussed briefly, and identified with so-called caustic-embrittlement, which occurs when highly stressed steel is in contact with concentrated caustic. *Tube* embrittlement was identified as a type of more recent origin, occurring in steaming tubes where factors causing film-boiling occur. He mentioned the highly favorable results obtained with embrittlement detectors to determine a priori the embrittling characteristics of water as referred to the *classical* type, and the use of inhibitors, such as tannin and nitrate ion, to prevent embrittlement failures.

Regarding the *tube* embrittlement type, however, little is known in so far as protective measures are concerned. Dr. Hall mentioned that some measure of protection is afforded by what he termed "precision low phosphate control," and emphasized that *coordinated phosphate control* (Purcell and Whril) and the newer technique are incompatible and incapable of simultaneous use.

STEAM-PURITY TESTING.—There was considerable discussion of the methods in use for testing steam purity, and Dr. Hall referred constantly to the ASTM "Symposium on Problems and Practice in Determining Steam Purity by Conductivity Methods," commenting on the general excellence of this publication. It was pointed out that complete degassing of the sample for the conductivity determination is much preferred to the partial degassing and application of correction factors that is frequently practiced. He mentioned some of the shortcomings of the present methods, such as their inability to indicate organic contamination or silica volatilized from the boiler; but stated his belief that in so far as silica is concerned, it was better to fix the SiO_2 in the boiler water in non-volatile form, rather than to indict the conductivity method.

CONTROL OF CORROSION AND DEPOSITION IN THE BOILER.—Dr. Hall stated that everything economically possible should be done *outside* the boiler to provide good feedwater, and to give the water the minimum dosage of chemicals *inside* the boiler that will provide adequate protection. It was emphasized particularly that condensers on salt water service must be kept tight if trouble from magnesium is to be avoided.

He asked rhetorically "should the use of some chemicals be curbed?" and directed attention to Na_2SO_3 as an oxygen scavenger. He expressed the opinion that in low-pressure plants, where deaeration is apt to be deficient, the excess sulfite may be 10–30 ppm, but that in high-pressure plants, it should be kept at 5 ppm or less.

Regarding phosphate, Dr. Hall stated that it has been well established that for ordinary alkalinities in the boiler water, the calcium will form hydroxyapatite when the phosphate excess is less than 50 ppm, and whitlockite when the excess is high, but that calcium silicate or hydroxide will not form so long as phosphate is present at all. He concluded that the best

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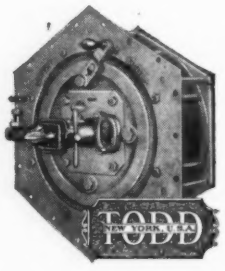

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way to prevent magnesium phosphate, a sticky, adherent deposit, from forming was to establish equilibria in the water so that serpentine, a magnesium silicate, is formed. The use of dispersion agents, such as lignin, have been found effective when the presence of magnesium phosphate is unavoidable. At low operating pressures the formation of serpentine appears to be favored by limiting the concentration of reserve phosphate, by limiting the alkalinity to the minimum required, and by maintaining sufficient silica in the water so that the solubility product of magnesium silicate, rather than the phosphate, is exceeded.

Treatment at Higher Pressures

At 600 psi and higher, where the makeup is small, dispersive agents are not as effective as direct treatment of the water, according to Dr. Hall. The conditions necessary to establish these equilibria were discussed recently in a paper by F. H. Long of the Wisconsin Electric Company. In general, the phosphate must be kept at 2 to 3 ppm PO_4, the pH of the boiler water between 10.8 and 11.0, and the silica under 5 ppm.

He concluded with the statement that precision control seems the only feasible means of preventing tube embrittlement in high-pressure boilers.

Messrs. I. B. Dick of Consolidated Edison Company, R. W. Senniff, of the B&O RR., and H. A. Grabowski, Combustion Engineering Company, discussed Dr. Hall's paper, the consensus being that precision control of boiler water has merit, from both theoretical and practical standpoints.

Panel Discussion of Power Station Design as Related to Boiler Feedwater Degasification

The following took part in a discussion of the merits of complete deaeration of feedwater in the surface condensers versus deaerating heaters:

R. B. Donworth, Duquesne Light Company
D. S. McKinney, Carnegie Institute of Technology
G. C. Daniels, Commonwealth & Southern Corporation
W. H. Armitage, Allis-Chalmers Manufacturing Co.
S. D. Fulton, Westinghouse Manufacturing Company
L. E. Hankison, West Penn Power Company
S. B. Applebaum, Liquid Conditioning Corporation
J. D. Yoder, Permutit Company
L. A. Winkelman, Public Service Electric and Gas Co. of N. J.
A. L. Jones, Worthington Pump and Machinery Company
E. B. Kuhn, Elliott Company

R. B. Donworth led the discussion by defining the problem and giving a short history of the developments in power-plant practice that led to the use of deaerators. He was of the opinion that deaerating of the main condensate in the surface condenser was the most logical and cheapest practice, and advocated the use of a small deaerator to degasify drips, etc., and to purge the condenser on starting.

D. S. McKinney discussed briefly the physical chemistry of degasification, indicating that the rate of degasification is the most important factor to be considered, a factor unique to each installation, and that turbulence is essential.

G. C. Daniels cited the gradual trend toward deaeration in the main condenser. He attributed dissolved oxygen in the plants of his company in the early days to lack of attention to the water level in the hotwell. He aroused interest by suggesting that too much emphasis has been placed on oxygen removal, and that a small amount to oxygen in the feed might be beneficial.

W. H. Armitage mentioned that his company has had no difficulty designing condensers to give less than 0.01 cc per liter of oxygen. The main problem seems to be to prevent subcooling of the condensate; that is, designing so that only the latent heat of the turbine discharge is removed.

S. D. Fulton (substituting for P. L. Fetzer) stated that Westinghouse has no preference for degasification in the surface condenser or by deaerators. He mentioned, however, that it is more difficult to meet guarantees with surface condensers, and emphasized that the cold makeup should not exceed 5 per cent of the condensate, and that the sampling procedure must be mutually satisfactory to the company and the customer. Further, the location of vents and drains must meet the requirements of the manufacturer of the equipment.

L. E. Hankinson mentioned that he preferred the use of an oxygen scavenger chemical to remove the last traces of dissolved oxygen. It was his opinion that condenser deaeration is conducive to good plant housekeeping.

S. B. Applebaum thought that comparative studies should be made to establish the advantages of one method or the other.

J. D. Yoder thought that some consideration should be given the tendency for iron and copper to be dissolved from preboiler equipment and carried into the boiler where tube damage may occur. He thought that deaeration should aim to produce the minimum CO_2 in the feed, and that high-pressure deaerators are the best.

L. A. Winkelman thought that condenser deaeration was equal to or better than deaerating heaters.

A. L. Jones discussed the pros and cons of both methods, based upon several installations. He cited two schemes that are used: (1) partial deaeration in the main condenser followed by final deaeration in a heater, and (2) partial deaeration in the main condenser followed by a special deaerating hot well.

E. B. Kuhn gave comparative costs of installations employing deaerating heaters and condenser deaeration of the feedwater.

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A.S.M.E. Annual Meeting Program Briefed

COINCIDENT with the 18th National Power Show, the Annual Meeting of the American Society of Mechanical Engineers will be held in New York City, N. Y., from November 28 to December 3 at the Hotel Pennsylvania.

There will be around eighty technical sessions with more than two hundred papers covering a wide range of interests in mechanical engineering and related fields. In addition to the technical sessions, the A.S.M.E. will have the distinction of participating on America's Town Meeting of the Air on Tuesday, November 30, from 8:30 to 9:30 p.m., E.S.T., on the nationwide network of the American Broadcasting System and the television facilities of Station WJZ-TV, Channel 7.

In the listing which follows only those papers which have identification with the power plant field have been noted. Persons desiring to attend the sessions are cautioned not to regard the program which follows as the final one. Those who plan to come long distances for attendance at specific sessions are advised to confirm dates and times by wire with A.S.M.E. Headquarters prior to journeying to New York City.

Papers of interest to those in the power field are scheduled as follows:

Monday, Nov. 29, 9:30 a.m.

"Mechanical Cleaning of Fouled Heat-Exchanger Tubes," by Alexander John, Jr., Thos. C. Wilson, Inc.

"Chemical Cleaning of Heat-Exchange Equipment," by C. M. Loucks and C. H. Groom, Dowell, Inc.

"Scale Formation and Control in Compression Distillation of Sea Water," by J. J. Campobasso, E. D. Badger & Sons, and A. Latham, Jr., Arthur D. Little, Inc.

"Inhibited Acid Cleaning of Nonferrous Condenser Tubes," by F. J. Allen, York Corporation.

"Symposium on Heat Balance," sponsored by the Hydraulic Division.

Monday, Nov. 29, 2:30 p.m.

"Cleaning Tubular Heat Exchangers," by P. F. Dougherty and C. H. Brooks, Sun Oil Company.

"Current Practices in the Cleaning of Marine-Type Heat Exchangers," by H. E. Bethon, Bureau of Ships, Navy Department.

"Elements of Graphical Solution of Water Hammer Problems in Centrifugal Pump Systems," by A. J. Stepanoff, Ingersoll Rand Company.

"Pipe Factors for Quantity Rate-Flow Measurements with Pitot Tubes," by R. G. Golsom, University of California.

"The Measurement of Turbulent Components in a Liquid in Pipe Flow by the Method of Electromagnetic Induction," by L. M. Grossman, University of California.

"Mechanical Investigations of Gas-Turbine Components," by Carl Schabtach, General Electric Company.

"Current Design Practices for Gas-Turbine Power Elements," by H. D. Emmert, Jr., Allis-Chalmers Manufacturing Company.

"Heat Engines Based on Wave Processes," by Arthur Kantrowitz, Cornell University.

Monday, Nov. 29, 8:15 p.m.—Panel Discussion

"Nature of Deposits," by L. F. Collins, The Detroit Edison Company.

"Problems in Steam Power Plants," by W. L. Webb, American Gas & Electric Service Corporation.

"Problems in Marine Power Plants," by D. F. Kinert, commander, U.S.N., Bureau of Ships, Navy Department.

"Fouling and Cleaning Problems Pertaining to Process Industries," by R. L. Clapper, Griscom-Russell Company.

"Influence of Fouling on Design of Heat Exchangers," by R. M. Armstrong, Downingtown Iron Works.

"Gas-Turbine Locomotive Units—Combustion Chamber Development for Burning Heavy Oil," by B. O. Buckland and D. C. Berkey, General Electric Company.

"Effects of Fuel Properties on the Performance of the Turbine-Engine Combustor," by L. C. Gibbons, National Advisory Committee for Aeronautics.

"NACA Research on Cooling of Gas-Turbine Blades," by O. W. Schey, National Advisory Committee for Aeronautics.

Tuesday, Nov. 30, 9:30 a.m.

"A 5000-Kw Gas Turbine for Power Generation," by Alan Howard and C. J. Walker, General Electric Company.

"Test of a 4800-Hp Gas-Turbine Power Plant," by Alan Howard and B. O. Buckland, General Electric Company.

"A Study of Three Tube Arrangements in Unbaffled Tubular Heat Exchangers," by O. P. Bergelin, E. S. Davis and H. L. Hull, University of Delaware.

"Cooling-Tower Analysis," by Joseph Lichenstein, Foster-Wheeler Corporation.

"Errors in High-Temperature Probes for Gases," by E. M. Moffatt, The Airflo Instrument Co.

Tuesday, November 30, 12:15 p.m.—Power Luncheon

Presiding: J. I. Yellott, Locomotive Development Committee.

Speaker: Joseph Pope, Stone & Webster Engineering Corporation.

Subject: "Utility and Industrial Cooperation in Generation and Use of Steam and Electricity."

Tuesday, November 30, 2:30 p.m.

"Pressure Vessel Design Theory on Measured Versus Computed Stresses in Head-to-Shell Juncture," by R. G. Sturm, H. G. Larew, H. L. O'Brien, E. Wetterstrom, H. W. Marsh and J. Evans, Purdue University.

"The Effect of Fabrication Processes on Steels Used in Pressure Vessels—Progress Report No. III—Effect of Plastic Strain and Heat-Treatment on Tensile and Notch Properties of a Rimmed and a Killed Steel," by C. J. Osborn, A. F. Scotchbrook, R. D. Stout and B. G. Johnston, Lehigh University.

Tuesday, November 30, 3:00 p.m.

"Power-Plant Cycle Evaluation," by J. K. Salisbury, General Electric Company.

Tuesday, November 30, 6:00 p.m.—Gas Turbine Power Dinner

Speaker: Walker Cisler, The Detroit Edison Co.

Subject: "The Gas Turbine's Place in The World Power Field."

Tuesday, November 30, 8:15 p.m.

Presiding: M. D. Engle, Pennsylvania Power & Light Co.

Panel Discussion: Progress in Automatic Control of Steam Plants. A panel composed of representatives from utility plants, industrial plants, consulting engineers, and automatic control manufacturers will lead the discussion.

Wednesday, Dec. 1, 9:30 a.m.

"Catalytic Cracking Plants for Relieving Gas Utility Peak Loads," by C. G. Milbourne, Surface Combustion Corporation.

"A Ventilated Thermal Insulation Structure for High-Temperature Marine Power Plants," by A. L. London and C. R. Garbett, Stanford University

"Operating Experiences in Connection with Regenerative Reheat Turbine Installations," by C. A. Robertson, Allis-Chalmers Manufacturing Company.

"Developments in Resuperheating in Steam-Power Plants," by E. E. Harris and A. O. White, General Electric Company.

"Steam Turbines for Reheat Cycle," by E. E. Parker, General Electric Company.

"Reheating in Steam Turbines," by R. L. Reynolds, and H. R. Reese Westinghouse Electric Corporation.

Wednesday, Dec. 1, 12:15 p.m.—Fuels Luncheon

"Synthetic-Liquid-Fuel Research" by W. C. Schroeder, U. S. Bureau of Mines.

Wednesday, Dec. 1, 2:30 p.m.

"Steam-Generating Equipment for Resuperheating Cycles," by Martin Frisch, Foster Wheeler Corporation.

"High Pressure Boilers with Reheaters," by W. H. Rowand, The Babcock & Wilcox Company.

"Modern Reheat Boilers," by W. S. Patterson, Combustion Engineering Company, Inc.

"Combustion Ash Collection for the Small Power Plant," by Phillip F. Best, Thermix Corporation.

"How to Cut Small Boiler-Plant Costs by Mechanical Coal and Ash Handling," by C. E. Miller, H. M. Carlson and R. B. Engdahl, Battelle Memorial Institute.

"Studies on Fly-Ash Erosion," by M. A. Fisher and E. F. Davis, Armour Research Foundation.

Thursday, Dec. 2, 2:00 p.m.

"Corrosion of Boiler Generating Tubes at Battersea and Deptford West Generating Stations," by R. L. Rees and E. A. Howes, British Electricity Authority, London, England.

"Hydrogen Embrittlement of Heat-Transfer Surfaces in Power Boilers," by E. P. Partridge, Hall Laboratories.

"Corrosion-Erosion of Boiler Feed Pumps and Regulating Valves at Marysville, Second Test Program," by H. A. Wagner, J. M. Decker and J. C. Marsh, The Detroit Edison Company.

Thursday, Dec. 2, 8:15 p.m.

"Marine Propulsion Gear Testing of the Naval Boiler and Turbine Laboratory," by Ivan Monk, commander, Philadelphia Naval Shipyard.

"Machinery Installation in New Coast Guard Ice Breakers," by E. H. Thiels, captain, U. S. Coast Guard Headquarters.

"Cause Analysis of Boiler and Machinery Accidents," by H. W. Heinrich, Travelers Insurance Company.

Friday, Dec. 3, 9:30 a.m.

"Southwark Station Boiler Air-Flow Model Tests and Operation Results," by R. A. Lane, Philadelphia Electric Company, and E. L. Morrison, The Babcock & Wilcox Company.

"External Corrosion of Furnace-Wall Tubes, III: Further Data on Sulphate Deposits, and Significance of Sulphide Deposits," by R. C. Corey, U. S. Bureau of Mines, H. A. Grabowski and B. J. Cross, Combustion Engineering Company, Inc.

"Methods and Instrumentation for Furnace Heat Absorption Studies: Temperature and Composition of Gases at Furnace Outlet," by Paul Cohen, R. C. Corey and J. W. Myers, U. S. Bureau of Mines.

"Boiler Model Scenes and Flame Travel in the Southwark Boilers"—Motion Picture.

Friday, Dec. 3, 2:30 p.m.

"Cyclic Heating Test of Main Steam Piping Joints Between Ferritic and Austenitic Steel at Sewaren Generating Station," by H. Weisberg, Public Service Electric and Gas Company.

"Report on Graphitization Studies on High-Temperature Welded Piping of the Philadelphia Electric Company," by J. B. Abele, Philadelphia Electric Company, and A. E. White, University of Michigan.

Items of General Interest

Monday, Nov. 29, 12:15 p.m.—Keynote Luncheon

Speaker: L. A. Appley, president, American Management Association.

Subject: "Opportunity for and Responsibility to the Young Graduate Engineer in Industry."

Monday, Nov. 29, 2:30 p.m.—Keynote Session

"Expanding Opportunities for Engineers in Industry—Whither Engineering Employment?" by A. A. Potter, Purdue University.

"The Government and the Future Employment of Engineers," by M. W. Trytten, National Research Council.

"The Small Manufacturing Company as an Opportunity for Engineering Graduates," by Crosby Field, Flakice Corporation.

Tuesday, Nov. 30, 9:30 a.m.

"What Is Being Done in Recognizing or Finding the Qualities Essential to Creative Engineering?" by Kenneth W. Vaughn, Pinecrest Farm, Hyde Park-on-Hudson, N. Y.

Tuesday, Nov. 30, 8:30 p.m.

America's Town Meeting of the Air Program sponsored by A.S.M.E. Engineers Civic Responsibility Committee and broadcast from radio station WJZ and television station, WJZ-TV, Channel 7.

Wednesday, Dec. 1, 6:30 p.m., Annual Dinner

Speaker: E. G. Bailey, president, A.S.M.E.

Subject: "Engineering Opportunities in Industry."

Friday, Dec. 3, 2:30 p.m.

"The Challenge Facing Colleges Today," by Kenneth R. Fox, Lowell Textile Institute.

Average American Coal Seams

According to information furnished by the U. S. Bureau of Mines, bituminous coal and lignite seams of the United States and Alaska range from less than 2 ft in thickness to more than 50 ft, although the majority of the nation's coal mines produce from seams 3 to 6 ft thick and the average for the country is 65 in. About one-third of the coal comes from mines operating seams over 6 ft.

Mechanization in mining has been responsible for greatly increased tonnage output per man-day. In the last 25 yr this has increased some 45 per cent, the average in 1945 being 5.78 tons. Cutting equipment is now used in 91 per cent of the underground mines and mechanical loading in 56 per cent.

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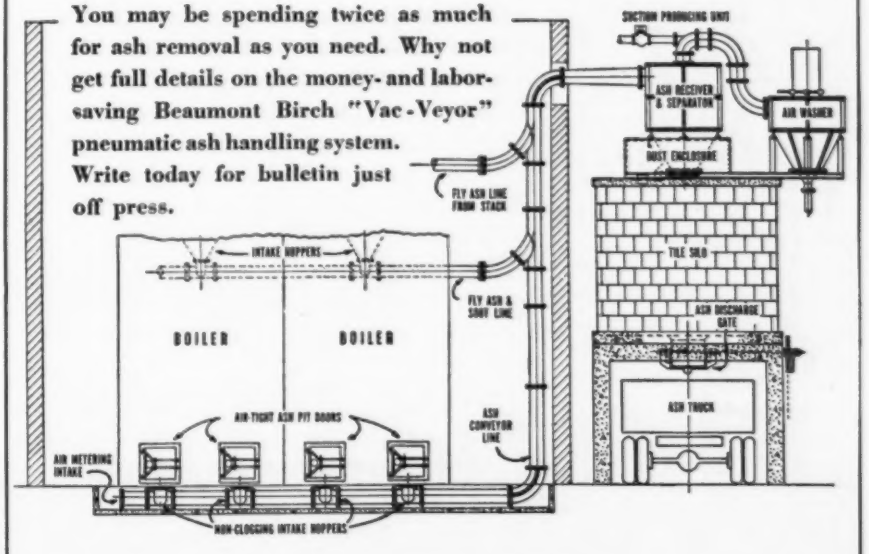

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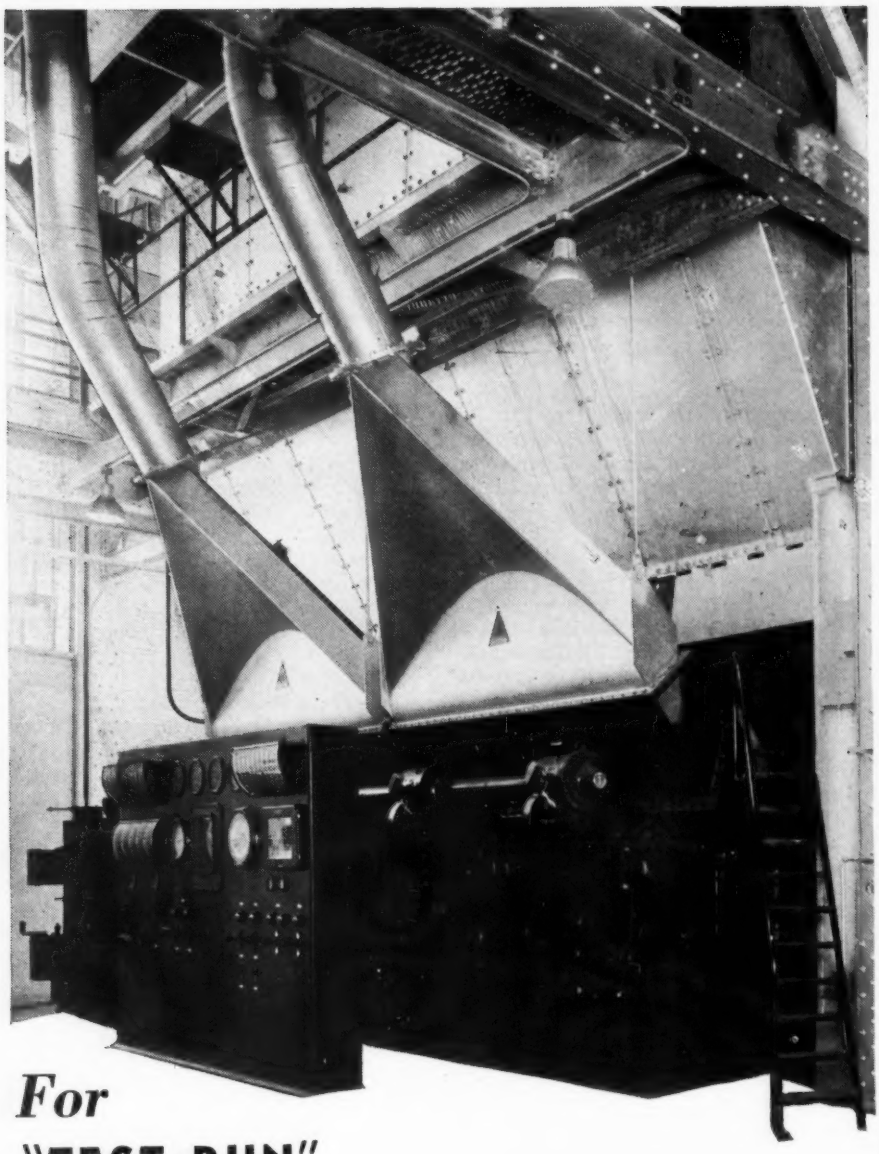

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Piping Code to be Revised

The American Standard Code for Pressure Piping, safety standard for all steam and power services, is to be completely revised within the next two years, according to Frank S. G. Williams, new chairman of the committee which functions under A.S.M.E. sponsorship. At a recent organization meeting plans were announced for bringing the Code abreast of current developments in the field of materials, design and construction.

Originally organized in 1926, the committee includes representatives of groups primarily concerned with safety of high-pressure piping systems. Members-at-large are recognized experts in the piping field. Specific subcommittees have been appointed to revise sections of the Code on (1) power piping systems, (2) gas and air piping systems, (3) oil piping systems, (4) district-heating piping systems, (5) refrigeration piping systems, (6) fabrication and (7) corrosion-service piping. A second group of subcommittees include (1) materials and stresses, (2) standards and identification, (3) instrument piping, (4) mechanical design, (5) liaison with A.S.M.E. Boiler Code Committee and (6) welding procedures and qualification.

Subjects which cross all fields of service, such as instrument piping and mechanical design, will be handled by separate technical committees. It is proposed to recognize liaison with other code-making bodies as a major function and responsibility to eliminate overlapping of jurisdiction and achieve uniformity. The A.S.M.E. Boiler Code Committee already has formed subcommittees to establish allowable stresses for materials. It is proposed to cooperate with this group rather than duplicate the activity.

The field of "corrosion-service" piping is new to the Committee. It includes stainless steel, nickel, Inco alloys, aluminum and copper. These materials, their use and methods of fabrication differ from steel to an extent that separate handling is justified.

Site for New Atomic Power Reactor

The United States Atomic Energy Commission has announced that it will acquire 4500 acres of land in Saratoga County, N. Y., as the location of an experimental atomic power plant for studies of the generation of electric power from nuclear energy. The plant will be part of the facilities of the Knolls Atomic Power Laboratory, operated for the Commission by the General Electric Company at Schenectady.

The new Knolls reactor is one of two now being designed especially for the study of high-temperature operation and the production of power. A different type of reactor but for a similar purpose is planned at the Argonne National Laboratory near Chicago. The design of both these reactors is directed to the problem of power generation by nuclear fission but by different methods, and both are expected to yield important data leading ultimately to the design of reactors which

will produce power on a practical scale. They will also be valuable in solving some of the problems involved in "breeding" nuclear fuel.

In the operation of a nuclear reactor, the fuel consumed consists of fissionable material which produces heat for conversion into power. If the so-called breeding process works as scientists have reason to expect, the reactor will more than replenish the fuel consumed in operation. In addition to producing heat, a breeder-type reactor would convert nonfissionable Uranium-238 into new fissionable matter.

The Knolls Atomic Power Laboratory was established in November 1946 to carry on research in all phases of atomic power development. It is located on a site of some 180 acres obtained from the General Electric Company and adjoining the company's own fundamental general research facilities, but this site is not large enough to accommodate the new reactor and generating system.

Choice of the location was guided by the need to have the project near enough to Schenectady to permit ready and frequent use of the extensive technical and scientific resources of the plant and laboratories of the General Electric Company. Other important considerations in selection of the site were availability of water and power and suitability of underlying formations for the installation of heavy concrete structures.

The size of the acreage to be acquired was determined by safety and security requirements and by the need to provide freedom of laboratory action in carrying out experimental work, including the handling of radioactive materials.

High-Temperature Ceramic Coatings for Molybdenum

The availability of materials suitable for use at higher temperatures than those in current use would effectively lessen design problems, making possible, for example, increased specific power in turbo engines. Because the requirements of stress and temperature for such increased performance are beyond the potentialities of the currently used high-temperature alloys, scientific investigations at the National Bureau of Standards have been directed toward the development of ceramic coatings for the metals having very high melting points, in order to protect them against oxidation at high operating temperatures. Preliminary results indicate that molybdenum with a specially designed ceramic coating offers a promising combination for such service.

The ceramic coatings developed to provide this protection to molybdenum are applied in the form of water suspensions or "slips" to cleaned specimens of molybdenum by either dipping or spraying. After drying, the pieces are fired at a temperature of 2150 F in oxygen-free atmospheres. The furnace is the only special equipment needed beyond that normally used in applying ceramic coatings.

Coated specimens were subjected to several significant performance tests during the Bureau's investigations and generally met expectations.

71-1-1

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Boiler Water Level Control

The Northern Equipment Company recently made available Bulletin No. 487, a Copes performance report on "Boiler Water Level Control at Blackhawk Station of Wisconsin Power and Light Company." In addition to describing the physical layout of the station, the 8-page bulletin pays particular attention to water-level control and contains reproductions of four charts illustrating the degree of control attainable.

Coal Crusher

The Pennsylvania Crusher Company has issued a new 16-page bulletin on coal preparation. Beginning with a historical account of the development of coal breakers, the bulletin then describes current practices in coal crushing at the coal mine and coal cleaning plant, the by-product coke plant, and the power station. Of especial interest to engineers engaged in power plant design are two pages of engineering data concerning crusher capacities, general dimensions, equipment weights, and required horsepower.

Conductivity Control

The Brown Instrument Company, a division of Minneapolis-Honeywell Regulator Company, has recently released Catalog 15-12 on conductivity and pH control. This 44-page bulletin illustrates methods of boiler condensate purity control along with industrial applications. It also offers a discussion of fundamentals of pH, oxidation-reduction potential, and conductivity. Descriptions of various instruments used in conductivity and pH control are included.

Corrosion in Boiler Systems

W. H. and L. D. Betz have designated as Betz Technical Paper No. 111 a reprint of an article from COMBUSTION entitled "Corrosion: Its Effect in Boiler Systems" by Robert L. Reed. This paper discusses the theories of corrosion, the action of oxygen in the boiler system and its removal by mechanical and chemical means, and the effects of carbon dioxide, ammonia, hydrogen sulfide and acidity together with appropriate corrective measures. Numerous illustrations, graphs and tables aid in understanding the article.

Electrostatic Precipitators

The Koppers Company has recently released two 4-page bulletins describing the Koppers-Elex electrostatic precipitator for "detarring" and for cleaning blast furnace gas. Each booklet illustrates representative installations and describes particular features of the equipment.

Jet Blowers and Blast Nozzles

Schutte and Koerting Company has just released Bulletin 4-AB describing steam jet blowers and blast nozzles for moving large volumes of gas at low drafts. Tables, charts and drawings, give complete data on dimensions, connection sizes, capacities and costs. Colored diagrams, with explanations, are used to illustrate typical applications of various types of blowers and blast nozzles.

Magnetic Pulleys

The Dings Magnetic Separator Company has issued two new 8-page catalogs of especial interest to present and prospective users of magnetic separator pulleys. Catalogue C-1001A describes the purpose, operation principle and advantages of Dings Electromagnetic Pulleys along with illustrations of actual installations and typical capacity and dimension tables. Catalogue C-1007A details the features of the newly developed Perma-Pulley which is of the non-electric, permanent magnet type. A practical section of both catalogs provides a ready reference to determine the proper size and type of pulley for particular requirements.

Overcoming Salt Corrosion

The International Nickel Company has recently released a 20-page booklet describing the part played by corrosion control in the production of salt and in the use of brine solutions by chemical and food processors. Following a discussion of the importance of purity in salt refining, the booklet indicates the importance of salt at work in the chemical process industries. Photographs of condenser circulating pumps exposed to untreated salt water are shown, and there are tables showing the corrosion rates of materials exposed to brine.

Pulverized Coal Firing

Combustion Engineering Company has issued a 24-page catalog illustrating basic C-E equipment for pulverized fuel firing. The catalog describes the process of preparing pulverized coal for firing, automatic control and types of burners. Latest improvements in mills and burners are shown in the 41 illustrations which make up this attractive two-color catalog.

Pressure and Vacuum Gages

The Brown Instrument Company has recently brought out a 32-page catalog on pressure and vacuum gages. It includes descriptions of various instruments, elements and control components as well as schematic diagrams illustrating fundamentals of liquid level measurement by electrical and pneumatic means.

W. H. Armacost Honored

The American Society for Metals at its meeting in Philadelphia, October 26, celebrating the Seventy-Fifth Anniversary of the first use of alloy steel in engineering construction, awarded **Wilbur H. Armacost,** vice president of Combustion Engineering Company, a Certificate of Merit for distinguished service in making notable contributions to the progress, development and use of alloy steels for engineering applications in America. Mr. Armacost's chief contribution, it will be recalled, has concerned alloys for high steam temperatures.

Rochester Gas and Electric Dedicates New Stations

On October 27, 1948, the Russell Station of the Rochester Gas & Electric Corporation was dedicated in honor of Herman Russell, president of the Corporation from 1929 to 1946. This new station is located in the town of Greece, N. Y., near the shore of Lake Ontario and has an initial installed capacity of 44,000 kw with a planned ultimate capacity of 220,000 kw. The plant while under design and construction was commonly referred to as the Lakeside Station.

At present, steam is produced at 1300 psi, 955 F by a 400,000-lb per hr, C.E. pulverized-coal-fired steam generating unit which serves a 44,000-kw turbine-generator.

The site of the plant covers 124 acres and is noteworthy in that an attempt has been made to landscape the grounds to harmonize with the natural beauty of the location. In the architectural treatment of the station itself, an attractive, modern building has been designed to fit the pattern of the surrounding region.

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Joint Fuels Meeting Features Coal Reserves and Synthetic Oils

AT THE Eleventh National A.I.M.E.—A.S.M.E. Joint Fuels Conference, held at White Sulphur Springs, Va., November 3–4, several papers held general interest for power men. These were "Work of the Geological Survey on Coal and Coal Reserves," by Paul Averitt of the U. S. Geological Survey; "Coal and Synthetic Liquid Fuels," by J. D. Doherty of the U. S. Bureau of Mines; and "Continental Fuel Utilization," by Carl E. Miller of Battelle Memorial Institute.

According to **Mr. Averitt,** the U. S. Geological Survey is making a completely new and detailed estimate of the coal reserves in the United States. This undertaking will bring up to date the currently used figures on U. S. coal reserves which were last revised in 1928. Although the entire project wil require approximately ten years for completion, the speaker pointed out that much specific information will be available meanwhile to satisfy existing needs.

The Geological Survey has in progress, as a part of this undertaking, thirteen detailed mapping projects, including the Pennsylvania anthracite field and fields in Maryland, Kentucky, North Carolina, Alabama, Montana, Wyoming, four fields in Colorado, and in New Mexico and Washington. These mapping projects include information on areas of outcrop of coal beds, their range in thickness, nature of roof rock, amount of overburden, correlation of the beds, stratigraphy and structure of the coal-bearing rocks, and the preparation of coal reserve figures based on those data.

The speaker emphasized the importance of indicating the bases of data in making coal estimates and illustrated the fallacy of attempting to compare estimates of coal reserves made on entirely different bases. He also indicated that in order to obtain and present its data on coal reserves to the greatest benefit of industry, the U. S. Geological Survey is working closely with coal resources committees of The American Institute of Mining and Metallurgical Engineers, the National Bituminous Coal Advisory Council and the Bureau of Mines.

A program for the production of one million barrels daily of synthetic oils from coal was outlined by **J. D. Doherty,** who called for immediate erection of some commercial plants for synthetic liquid fuels as a preparation for any possible emergency. To produce a million barrels per day would require a total investment of 8.7 billion dollars, according to the estimates of the Bureau of Mines, and would result in a production cost of approximately 12.5 cents per gallon.

Mr. Doherty declared that the day when synthetic oil from coal begins to supplement petroleum supplies is not far off. If a synthetic supply of liquid fuel is not made available, the only alternatives are the curtailment of oil consumption and increase of oil imports. While these expedients may serve for the immediate future, they will not solve the long-range problem, in the opinion of the speaker.

Under the contemplated program for producing synthetic fuel to the amount of a million barrels per day, coal resources from both east and west of the Mississippi would be utilized in approximately equal amounts to supply the estimated requirement of 575,000 tons per calendar day. Many new mines, particularly in the West, would have to be opened to obtain this production, and a marked increase in the mechanization of mining processes may be anticipated.

The Bureau of Mines is conducting research in both the gas synthesis and the coal hydrogenation processes for producing synthetic fuel. Leading oil companies and other industrial firms are also carrying on extensive work, particularly on the gas synthesis process. Here one of the major problems is to find a means of directly gasifying coal rather than first coking it and then gasifying the coke. With widespread efforts to solve major problems of synthetic fuel production now under way, future progress may be anticipated.

According to **Carl E. Miller,** the United States, in cooperation with the United Nations Economic Commission for Europe, is making a concerted effort to improve fuel utilization practices and stop waste in European countries. This is a step which assumes even greater importance with recent changes of coal supply in certain European areas from a condition of shortage to one of relative surplus.

Mr. Miller pointed out that many of the surpluses are of lower grade fuels which require special technical knowledge for their maximum utilization. While many European users prefer the higher quality of coal imported from the United States, it is necessary that they be instructed in the effective use of low-grade fuels which will become increasingly available, particularly following the intensive mechanization of European mines.

E. G. Bailey, president of the A.S.M.E., addressed the annual banquet on the subject of "Engineers' Opportunities in the Field of Fuels."

The banquet was the occasion of the presentation of the Percy Nicholls Award of 1948 to Ralph A. Sherman, assistant director of Battelle Memorial Institute, Columbus, Ohio.

Also of interest to men in the power field was the presentation of a paper by **Elmer R. Kaiser,** assistant director of research for Bituminous Coal Research, Inc., Columbus, Ohio, discussing "Organizing and Financing Cooperative Research."

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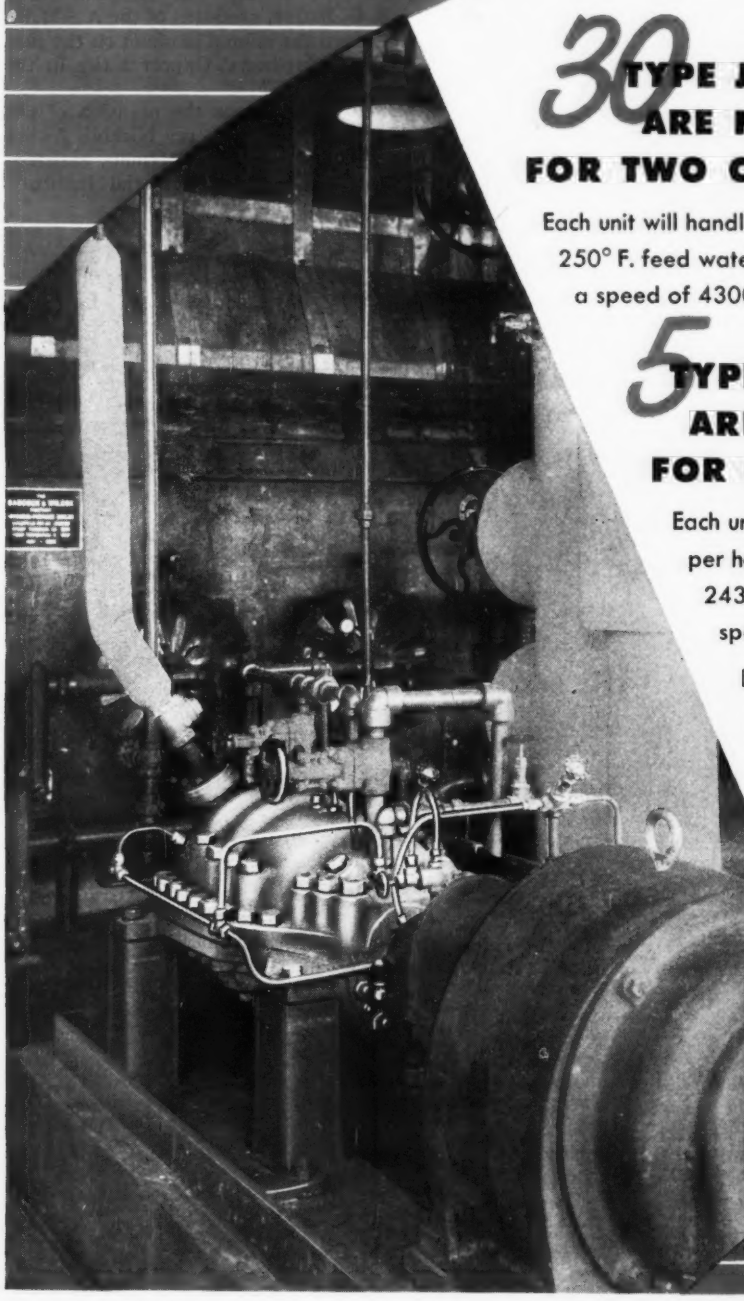

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